

NYASALAND PROTECTORATE



Annual Report
of the
Department of Agriculture
for the
Year 1959/60

(PART II)

PRICE 10s-0d

1961

PRINTED AND PUBLISHED BY THE GOVERNMENT PRINTER
ZOMBA, NYASALAND

AGRIC. 4380/600/5.61



DEPARTMENT OF AGRICULTURE

ANNUAL REPORT FOR THE YEAR 1959/60

(PART II)

C O N T E N T S

	PAGE
Introduction	3
Salient Points	4
List of Experiment Stations and Staff List	7
Maize	9
Other Cereals	29
Oil Seeds	32
Other Legumes	41
Root Crops	45
Tobacco	46
Cotton	59
Tea	91
Tung	127
Coffee	134
Fruit and Vegetables	152
Cocoa	156
Grassland	159
Rotation Experiments	168
Farming Systems	173
Chemical Weed Control (Chitedze)	178
Irrigation	181
Soil Survey	191
Pathology	202
Entomology	204

INTRODUCTION

This report describes the progress of agricultural research in Nyasaland during the year covering the 1959/60 rainy season and the ensuing dry season. It was a season which produced record crops of groundnuts and cotton, ample supplies of maize and a moderate tobacco crop of uneven quality. An outbreak of the disease *Alternaria* on the tobacco at the main experiment station severely affected the quality of the crop and hampered investigation of the components of quality in Burley and Western tobacco. Seasonal conditions interfered also with cotton pest research. Good progress was made with maize breeding and two newly introduced groundnut varieties of outstanding merit emerged. The supreme importance of early planting and proper garden preparation for maize and groundnuts was confirmed and the important point established that applications of nitrogenous fertilizer will not cancel out the effects of late planting of maize. Fertilizer is an essential ingredient of good farming practice and the effectiveness of the methods advocated by Chitedze as a result of research into the improvement of maize yields were demonstrated by the production of 33 tons of the variety Mthenga on 11 acres. The work on dark-fired tobacco confirmed the beneficial effect of nitrogen on the yield and showed that it increased both length and width of leaf. Significant advances were made in the knowledge of the biology of the Red Bollworm and in techniques of spraying to control this and other pests of cotton. An outstanding achievement of the year was the publication of a preliminary soil map of Nyasaland on the scale of 1 : 2,000,000.

2. Staff shortages have been a feature for so long as scarcely to require mention, but research in several important aspects has, during the year under review, run to some extent on the momentum generated by three experienced workers who left the Department in 1959 and have not yet been replaced. Mr. G. Jackson, Ecologist, took up an appointment at the University College of Ibadan after launching the agro-ecological survey of Nyasaland, which has been carried on very competently by the Soil Surveyor. Mr. R. T. Ellis, Botanist at Chitedze, whose maize breeding work has resulted in the production of a number of improved varieties mentioned in the Report, left to join the staff of the Tea Association of Nyasaland and Rhodesia. Mr. J. M. Munro, Cotton Specialist of the Empire Cotton Growing Corporation, who did much to advance our knowledge of the water relationships of crops in the Lower River area during his six or seven years in Nyasaland, was transferred on promotion to Nigeria. Mr. R. C. H. Sweeney, Entomologist, transferred from the Cotton Pest Research Scheme to fill the post of Entomologist at the Department of Agriculture Headquarters, caused by the resignation of Dr. G. W. Heath. Mr. J. S. Drummond, Agricultural Officer (Tobacco) at Chitedze, resigned. Mr. J. A. Seago, Agricultural Supervisor, took charge of the Tuchila station and Mr. Y. J. Kamponda the Chitala station.

3. In November, 1959, responsibility for tea research was taken over by the Tea Association of Nyasaland and Rhodesia, and the staff formerly employed by the Department under the direction of Mr. D. H. Laycock, Senior Tea Research Officer, was transferred to the new organization. Contact is preserved through the Tea Research Committee of which the Chief Agricultural Research Officer and the Senior Agricultural Chemist are members. A report on the progress of tea research during the past year is included by courtesy of the Directors of the Association. The Cotton Pest Research Scheme is financed jointly by the Agricultural Production and Marketing Board, the Colonial Development and Welfare Fund and the Federal Government. The Agricultural Production and Marketing Board also contributes to

tobacco research and the Empire Cotton Growing Association pays the salary of an officer at Makanga. The generous assistance given by these various bodies is gratefully acknowledged.

Salient Points

Maize breeding continues and the local hybrids are outstanding. Synthetic varieties, advanced generations of local hybrids and the open-pollinated Namlenga are approximately equal and considerably better than local unselected. There are signs that the newer synthetics may approach the yield of hybrids. Each year the fertilizer trials give a clearer picture of the most economic application of artificial fertilizer in different parts of the country.

Fertilizer experiments on **finger millet** show clearly that nitrogen application can replace the wasteful system of burning wood on the fields.

Rosette disease of **groundnuts** caused a severe loss of crop, especially in the Southern Province, and there are no varieties with proved resistance. The variety Mani Pintar has shown up well among the old types and has a high oil content, but it is not known if this would be suitable for the confectionery trade. The need for added sulphur in parts of the Northern Province has been confirmed.

Bambarra groundnuts yield well and have few disease or pest problems and it is a pity that there is not a wider demand for them. If some Science Foundation would discover a use for large quantities they could replace groundnuts in areas where rosette disease is serious. A fertilizer experiment on **sweet potatoes** rather surprisingly showed no response. The arrival of late blight in the country has caused a search to be made for **Irish potato** varieties which are resistant, and so far Walanga and Loman have shown most promise. A severe attack of *Alternaria* on dark-fired **tobacco** at Chitedze made quality assessment of experiments difficult. The value of fertilizer application and cultivation practices on yield was confirmed. The superiority of Barnet special **Burley** was again demonstrated. The proportion of "coloury" grades seems to be influenced more by the season than by fertilizer or agronomic methods.

The Albar 637 variety of **cotton** is being multiplied and further selection work continued. The **Cotton Pest Research** scheme has continued to do much fundamental work on the biology of Red Bollworm and Stainers and the results of investigation into control by spraying are about to be subjected to a full-scale test.

All experimental work on **tea** has now been transferred to the Tea Association and the full report is included as usual.

Although there is decreased interest in **tung** on account of falling prices the old experiments are continued and a new close spacing trial with a small vigorous type is just coming into bearing. Fertilizer experiments are showing that a higher rate of nitrogenous fertilizer may be used economically.

There are increased plantings of **coffee** and a good deal of experimental work on variety, shade, mulch and fertilizer has been done. There is special interest in the investigation into various forms of disease caused by *Fusarium*. **Fruit and vegetables** are not important economic crops but some work has been done on the best varieties to grow, their cultural requirements and control of disease.

For the first time **cocoa** is given a separate section. The experimental plots are growing well and if irrigation development takes place it could become an important crop. **Grassland** studies have given further information on the stocking rate of Rhodes grass leys. An experiment with Napier grass demonstrates the value of fertilizer application.

There are several experiments dealing with crop yields after a **rotation** which includes a grass ley and others showing the effect of one crop on another.

Chemical weed control is a new section on which work has been commenced though it may be some time before this method can be adopted on a wide scale.

Work on the intensive **farming system** using a Jersey herd as the main source of income continues and a start has been made for the small farmer with little capital by the Unit Farm approach.

Irrigation studies continue in order to establish the water requirements of crops grown in the lower part of the Shire Valley.

Work on an Agro-Ecological Survey was begun some years ago and during the past year the **Soil Survey** has been intensified. A preliminary soil map of Nyasaland has been published and a more detailed survey of one district is given in this report. Some readers may be disappointed at the absence of a section on **Agricultural Chemistry** and the small size of the report on **Entomology** and **Plant Pathology**. This is because the considerable amount of work accomplished on these subjects has been included with the crops on which the work has been done. Reference should therefore be made to each crop where the reports will be found.



Digitized by the Internet Archive
in 2025

LIST OF EXPERIMENT STATIONS AND STAFF LIST

The experiment stations in operation during the period under review, and the officers who have been in residence, are listed below:

Agricultural Research Station, Chitedze, Box 158, Lilongwe

Senior Agricultural Research Officer	..	H. B. AMBROSE, B.SC. (AGRIC.) (LOND.), DIP. AGRIC. (CANTAB.)
Agricultural Officer (Tobacco)	..	H. ROSTRON, B.SC. (LEEDS), D.T.A.
Agricultural Supervisor (Tobacco)	..	A. J. TALLACH, S.D.A., S.D.D.
Agricultural Officer (Agronomy)	..	P. BROWN, B.A. (CANTAB.), D.T.A.
Plant Breeder	.. ..	<i>Vacant</i>
Agricultural Chemist	.. ..	R. A. WOOD, B.SC. (MANCH.)
Assistant Chemist	.. ..	W. D. CHONA, B.SC. (RHODES)
Farm Manager	.. ..	P. F. LARKINS

Bvumbwe Tung and Agricultural Experiment Station, Box 48, Limbe

Agricultural Officer	.. ..	L. J. FOSTER, B.SC. (READING)
Senior Agricultural Chemist	.. ..	C. V. CUTTING, B.SC. (LOND.), PH.D., A.R.I.C.
Plant Pathologist (Coffee Research)	.. ..	M. A. SIDDIQI, M.SC. (ALIGARH), PH.D. (WALES)
Laboratory Technician	.. ..	R. C. PEAK
Farm Manager	.. ..	E. FABIAN, N.D.A., S.D.A.

Tuchila Experiment Station, Box 28, Luchenza

Officer in Charge		J. A. SEAGO, N.D.A., C.D.A.
-------------------	-------	-----------------------------

Makanga Experiment Station, Chiromo

Cotton Specialist (E.C.G.C.)	.. ..	J. M. MUNRO, B.SC. (EDIN.)
Agricultural Officer	.. ..	A. B. HEARN, B.SC. (READING), DIP. AGRIC. (CANTAB.), D.T.A.
Farm Manager	.. ..	D. F. COLLINGS, C.D.A.

Mwera Hill Experiment Station, Dowa

Officer in Charge		I. K. MSISKA
-------------------	-------	--------------

Chitala Experiment Station, Salima

Officer in Charge		Y. J. KAMPONDA
-------------------	-------	----------------

Mbawa Experiment Station, Mzimba

Officer in Charge		F. HIGSON
-------------------	-------	-----------

Provincial Agricultural Officers

Southern Province	.. ..	J. A. SANDYS, B.SC. (NOTTINGHAM)
Central Province	.. ..	H. W. T. WEBB, B.SC. (MCGILL), A.I.C.T.A.
Northern Province	.. ..	J. EVANS, B.SC. (READING) R. J. HARVIE, B.SC. (ALBERTA), D.T.A.

Headquarters, Zomba

Chief Agricultural Research Officer	..	..	..	S. T. HOYLE, O.B.E., M.A. (CANTAB.), A.I.C.T.A.
Entomologist	..	..	..	R. C. H. SWEENEY, M.I. BIOL., F.R.E.S.
Ecologist	..	..	..	<i>Vacant</i>
Plant Pathologist	..	..	..	D. C. M. CORBETT, B.SC. (ABERD.), DIP. AGRIC. SC. (CANTAB.), D.T.A.
Soil Surveyor	..	..	..	A. YOUNG, M.A. (CANTAB.), PH.D. (SHEFFIELD)

Cotton Pest Research Scheme

Officer in Charge (Gatooma)	..	..	..	J. P. TUNSTALL, B.SC., DIP. AGRIC. (READING), A.R.C.S.
Entomologist	..	..	..	G. A. MATTHEWS, B.SC., A.R.C.S., F.R.E.S.
Entomologist (Makanga)	..	..	..	<i>Vacant</i>
Technical Assistant (Gatooma)	..	..	..	A. A. RHODES
Technical Assistant	..	..	..	I. MACDONALD

MAIZE

Breeding Work

1. GENERAL

The season was a favourable one for maize in the Central and Northern Province plateau where trials were carried out at Chitedze and Mbawa respectively, and gave high yields. In the Southern Province and on the Central Province Lake-shore climatic conditions were less satisfactory for the crop. The breeding programme continues to develop satisfactorily, and it is apparent that the existing material holds promise for further improvement. The main problem is still the combining of really flint grain and very good tip coverage with the high yields already being obtained in crosses that are good, but not excellent, with regard to these other characters.

The majority of the formal experiments were carried out on chocolate, sandy clay loam soils at Chitedze. Plot sizes are indicated for each experiment and the plots consisted in each case of single rows, either 5 or 10 yards long, with 3 feet between rows and 1 foot between plants spaced singly in the row.

2. INBREEDING AND TESTING INBRED LINES

The most advanced group of inbreds grew as S.10 plants. There have been several subsequent introductions of collections, and the last of these, made in 1956, provided 52 lines, S.2, which were used in top crossing onto Namlenga in 1958/59. The resultant top cross yield trial was put down as six replications of a randomized block layout with plots of single 5 yard rows. It gave a mean yield of 5,888 lb. per acre. Nine of the crosses yielded significantly more than the mean, the highest yield being 7,809 lb. per acre. The coefficient of variation was 13.46 per cent. for the trial. Of the nine highest yielding crosses six showed good or very good tip coverage, combined with medium flint grain and below average scores for *Puccinia sorghi* incidence. *Helminthosporium* leaf disease was generally light.

3. MAIZE VARIETY TRIALS

These trials were again sited at five stations as in previous years. There were six randomized block replications at each site. Plots consisted of a single row 10 yards long. Coefficients of variation were very high at Tuchila and Makanga, and at the latter station on the Lower River conditions were generally very unfavourable with poor and variable stands and low yields. Consequently, the results of the experiment there are of doubtful value.

TABLE I
Maize Variety Trials
(Yields of grain (lb. per acre))

Variety			Chitedze Site I	Chitala Site II	Mbawa Site III	Tuchila Site IV	Makanga Site V	Mean % of local unsel. omitting Site V
1.	Local Unselected	.. ..	4,503	2,372	4,413	2,646*	847*	—
2.	Namlenga	.. ..	6,456	2,759	3,751	1,863	347	103
3.	Local Hybrid	No. 2 F.1	6,706	2,823	4,340	1,750	—	108
4.	"	No. 2 F.2	5,665	2,065	3,662	2,122	—	94
5.	"	No. 2 F.4	4,850	2,444	2,904	1,734	—	85
6.	"	No. 7 F.1	7,465	4,251*	5,243*	3,219*	306	145
7.	"	No. 7 F.2	6,149	2,993	4,154	2,041	258	108
8.	"	No. 10 F.1	7,917*	3,864*	5,139*	2,573*	734	138
9.	"	No. 10 F.2	7,037	3,041	4,098	2,372	427	116
10.	"	No. 11 F.1	7,360	3,662*	5,252*	2,856*	444	136
11.	"	No. 12 F.1	8,457*	3,686*	4,308	2,485*	694	133
12.	"	No. 12 F.2	5,907	2,275	4,146	2,065	387	99
13.	"	No. 13 F.1	7,610*	3,372*	4,542	2,234	581	124
14.	"	No. 14 F.1	6,375	3,751*	5,389*	3,033*	331	134
15.	"	No. 15 F.1	7,190	3,259	4,889*	3,017*	298	130
16.	Syn. Var. Mlonda	F.1	5,689	3,049	3,315	2,283	879*	104
17.	"	F.2	6,214	2,799	3,880	1,920	1,032*	104
18.	"	F.3	6,383	3,235	3,695	1,920	863*	108
19.	"	No. 7 F.4	5,246	2,259	3,525	2,178	—	93
20.	"	No. 8 F.3	6,521	3,445*	4,630	1,863	—	116
21.	"	No. 10 F.2	5,964	2,718	3,832	1,742	—	99
22.	"	No. 12 F.3	5,899	3,081	4,372	1,226	—	101
23.	"	No. 14 F.3	6,335	3,049	3,614	1,750	—	104
24.	"	No. 15 F.3	5,673	2,944	4,558	1,904	—	106
25.	"	No. 16 F.3	7,069	3,243	4,655	2,073	—	119
26.	"	No. 17 F.3	6,956	3,009	4,743	1,912	573	115
27.	"	No. 18 F.3	6,972	2,936	4,090	2,162	—	113
28.	"	No. 19 F.3	6,391	3,461*	4,743	1,944	—	117
29.	"	No. 20 F.2	5,802	2,799	4,340	2,388	—	109
30.	"	No. 21 F.2	8,086*	3,202	4,267	2,622*	—	127
31.	"	No. 22 F.2	7,247	3,219	4,558	2,162	—	119
32.	"	No. 23 F.2	5,980	3,081	3,638	1,799	—	103
33.	"	No. 26 F.2	5,697	3,081	4,227	1,621	315	103
34.	"	No. 24 F.2	6,246	—	—	—	508	138
35.	"	No. 25 F.1	5,455	—	—	—	895*	121
36.	"	No. 27 F.1	6,383	—	—	—	928*	141
37.	"	No. 28 F.1	6,295	—	—	—	1,024*	139
38.	"	No. 29 F.2	7,336	—	—	—	—	162
39.	"	No. 30 F.2	6,545	—	—	—	—	145
40.	"	No. 31 F.2	8,280	—	—	—	831*	183
41.	"	No. 32 F.2	6,706	—	—	—	—	148
42.	"	No. 33 F.1	7,545	—	—	—	669	167
43.	"	No. 34 F.1	5,923	—	—	—	879*	131
44.	"	No. 35 F.1	7,917*	—	—	—	508	175
45.	"	No. 36 F.1	7,215*	—	—	—	887*	182
46.	"	No. 37 F.1	7,190	—	—	—	823*	159
47.	"	No. 38 F.1	6,545	—	—	—	750	145
48.	"	No. 39 F.1	7,973*	—	—	—	524	177
49.	"	No. 40 F.1	7,125	—	—	—	694	158
Mean			6,641	3,067	4,270	2,166	641	—
Least Significant diff. 5% ..			896 lb.	944	565	799	258	—
Least Significant diff. 1% ..			1,178 lb.	1,250	742	1,049	339	—
Coefficient of Variation ..			11.9%	27.0%	11.5%	32.1%	35.0%	—

* Top yielding varieties not differing significantly from the highest yielder at the 5 per cent. probability point.

At the other sites the top yielders are, as was the case last year, mainly found in the local hybrids Nos. 6 to 15. Local hybrid No. 7 yielded well, and considering other characters continues to justify its choice as the first hybrid to be multiplied for issue in the country. As such it is the subject of a special report below.

The Synthetic varieties include a number of high yielders in the F.1 generation and Synthetic Variety No. 21, F.2, repeats its successful performance in the F.1 generation last year. The standard open pollinated variety Namlenga is below the mean yield at every site and has now been left well behind by the better Chitedze Hybrid Varieties.

The figures given for mean percentages of Local Unselected in the last column of Table I need treating with special reserve from Nos. 34 to 49 as they are based only on Site I results where the Local Unselected is particularly low yielding in relation to the bred varieties.

4. HYBRIDS YIELD TRIAL

A yield trial, containing 25 double cross hybrids and 70 single cross hybrids with Namlenga, the best open pollinated variety available as control, was run at Chitedze with a total of 98 treatments in six replications of randomized blocks design.

The two additional treatments were Local Unselected and Synthetic Variety 17. Plot size was 5 square yards, each plot being a single row 5 yards long. The coefficient of variation was 14.6 per cent. The mean yield was 7,446 lb. of grain acre. Of the double crosses 10 were significantly higher yielding than Namlenga which yielded 5,699 lb. per acre. The least significant differences were:—5 per cent. 1,240 lb. per acre; 1 per cent. 1,633 lb. per acre; 0.1 per cent. 2,082 lb. per acre. Three of the 11 double crosses outyielded Namlenga at 0.1 per cent. level of significance, five at the 1.0 per cent. level and two at the 5 per cent. level. Local Hybrid No. 7, Mthenga, was one of those at the 5 per cent. level, and it is apparent that the breeding material in hand will be able to give even higher yielding varieties than Mthenga in the future. Most of these high yielding double crosses were at least equivalent to Mthenga in the combination of disease resistance, tip coverage and flintiness of grain.

The single crosses of established Nyasaland inbred lines on to Mexican inbreds produced a number of promising crosses combining high yield with hard grain and good tip coverage. 39 crosses between the Southern Rhodesian inbred N2656 and Nyasaland inbreds produced many high yields with good tip coverage, but grain quality was generally tending towards dent, with one or two notable exceptions.

5. SYNTHETIC VARIETIES YIELD TRIAL

This trial consisted of 52 treatments replicated six times in randomized blocks at Chitedze on plots of 10 square yards, similar to those of the variety trial reported at 3 above. Local unselected, Namlenga and the F.1 and F.2 generations of L.H. No. 7, formed a group of controls. Against these were compared 23 synthetic varieties and L.H. No. 7 $\times$ a good tip coverage synthetic. All but six of the synthetics were represented by more than one generation. The object of the trial was to make straightforward yield comparisons, and to obtain information on the relative performance of synthetic varieties in the F.1, F.2 and more advanced generation.

TABLE II
Synthetic Varieties Trial
(Yields of grain in lb. per acre)

<i>Treatment</i>	<i>No. of Comparent Lines</i>	<i>Yield</i>	<i>Treatment</i>	<i>No. of Comparent Lines</i>	<i>Yield</i>
S.V. 1/2 F.1	24	5,084	S.V. 20 F.1	—	5,948*
F.2	24	5,536	F.2	—	5,609
S.V. 6 F.2	4	4,753	S.V. 21 F.1	—	5,560
F.3	4	4,713	F.2	—	5,480
S.V. 7 F.1	8	4,237	S.V. 22 F.1	—	6,416*
F.2	8	4,737	F.2	—	5,794
F.3	8	4,519	S.V. 23 F.1	—	4,947
F.4	8	4,882	F.2	—	4,511
S.V. 8 F.3	30	6,287*	S.V. 26 F.1	6	7,376*
S.V. 9 F.2	7	4,640	F.2	—	5,641
S.V. 12 F.2	8	5,318	S.V. 29 F.1	56	6,174*
F.3	8	5,431	S.V. 30 F.0	—	6,690*
S.V. 13 F.3	30	5,867*	F.1	—	6,585*
S.V. 14 F.1	80	5,915*	S.V. 31 F.1	49	6,182*
F.2	80	5,584	S.V. 32 F.1	—	6,093*
S.V. 15 F.1	50	5,851*	S.V. Mlonda F.1	9	5,060
F.2	50	5,584	F.2	9	5,835*
S.V. 16 F.0	40	5,480	(Good Tip Cov. Sel.) F.3	9	5,746*
F.1	40	5,673	(unselected) F.3	9	5,609
F.2	40	5,794*	L.H. No. 7 × Good		
S.V. 17 F.0	28	6,020*	Tip Coverage	38	5,100
F.1	28	6,133*	Local unselected	—	4,979
F.2	28	5,883*	L.H. No. 7 F.1	4	7,118*
S.V. 18 F.1	50	5,762*	F.2	4	5,899*
F.2	50	6,044*	Namlenga	—	5,964*
S.V. 19 F.1	12	5,197			
F.2	12	5,940*			
F.3	12	7,166*			

L.S.D. 5% = 766 lb. per acre

Coefficient of

L.S.D. 1% = 1,009 lb. per acre

Variation = 11.9%

* Denotes significantly greater than Local Unselected at the 5 per cent. point.

The mean yield, 5,659 lb. per acre, was slightly below the yield of Namlenga. Most of the higher yielding synthetics did not, in this trial, yield significantly more than Namlenga. The only exceptions were S.V. 19 F.3 and S.V. 26 F.1.

Comparison between F.1 and F.2 generations of the synthetics showed a significant increase in yield with Mlonda which was maintained into F.3, and a significant decrease with S.V. No. 26. The F.2 of S.V. 19 was almost significantly greater than the F.1, and the F.3 was very clearly so. Trends which did not reach significance were for an increase between F.1 and F.2 in four other synthetic varieties and for a decrease in seven more. There was no indication of any tendency for yields to fall after the F.2 generation.

6. LOCAL HYBRID NO. 7 (MTHENGA)

This double cross Hybrid, composed of single cross No. 93 (N2656 × R5125) × Single Cross No. 110 (Mex. 20 × L4161) has been an outstanding variety since 1957/58, when it was first introduced into the main variety trials. It was decided to proceed with multiplication in 1959/60 and approximately 33 tons of grain for seed has been produced off 11 acres of the female parent and this is being distributed to a large number of growers for consumer reaction in 1960/61. In 1959/60 the first extensive tests were carried out, first to further confirm the yield performance on stations, secondly to measure the actual yield drop from the F.1 to F.2 generation and, thirdly through the growing of one acre plots by African Master Farmers all over Nyasaland to get their comments.

TABLE III
Yield of Mthenga Maize (L.H. No. 7) to Standard Varieties
(Yield in lb. of grain per acre)

Site				Chitedze (1)	Chitala	Mbawa	Tuchila	Chitedze (2)	Mean
Variety									
L.H. No. 7	F.1	..	..	7,465	4,251	5,243	3,219	7,118	5,459
	F.2	..	..	6,149	2,993	4,154	2,041	5,899	4,247
S.V. Mlonda	F.1	..	..	5,689	3,049	3,315	2,283	5,060	3,879
	F.2	..	..	6,214	2,799	3,880	1,920	5,835	4,133
	F.3	..	..	6,383	3,235	3,695	1,920	5,677	4,182
Local Unselected		..	..	4,503	2,372	4,413	2,646	4,979	3,782
Namlenga	..	..	..	6,456	2,759	3,751	1,863	5,964	4,158

L.S.D. between two treatments means (P0.05)=792

Coefficient of Variation=14.2%

The results of these investigations can be summarized as follows. The yield performance in the F.1 generation has been confirmed. Yield data from the varieties trials and the Synthetic varieties trial are considered again in Table III, each site being taken as one replication of a trial comparing seven treatments. At the five sites, Mthenga F.1 gave a mean percentage increase over Local Unselected of 45 per cent., and a mean percentage increase over Namlenga of 40 per cent. The calculated drop in yield from F.1 to F.2 was 18.6 per cent. of the F.1 yield. This was calculated from the average yield of the parent lines grown at Chitedze and using the formula:

$$\text{F.2 Yield} = \text{F.1 Yield} - \left\{ \frac{\text{F.1—Average yield of parents}}{\text{number of parents}} \right\}$$

The actual drop on the two Chitedze sites was 17.62 per cent. and 17.13 per cent. The drop at the other sites was greater and the mean percentage drop for all sites is 24.34 per cent. Table III shows that this drop from F.1 to F.2 was significant at P0.05. The F.2 generation of Mthenga, and all the generations of Mlonda under test, showed no difference from Namlenga, the best open pollinated variety available, and were very close indeed to it in actual yield at every site.

Of the one-acre plots grown by farmers 27 were satisfactorily recorded and reported upon. Of these 25 per cent. remarked that the tip coverage could be improved, but almost all commented favourably on the yield, and many expressed interest in getting further supplies of seed. Six plots in Southern Province gave a mean yield of 3,063 lb., and three from Northern Province a mean yield of 2,755 lb. In the Central Province eighteen plots had a mean yield of 2,802 lb. per acre, and seven of these exceed 3,500 lb.

7. MAIZE SEED SIZE EXPERIMENT

An experiment was run at Chitedze with the object of ascertaining the effect of seed size on the growth and yield of maize. Three seed sizes were used; S.1 was grain passing over a 10 mm. sieve, S.2 was grain passing through 9 mm. and over 8 mm. sieve, and S.3 passed through a $7\frac{1}{2}$ mm. sieve. These treatments were superimposed as split plots on main plots consisting of four varieties, and arranged as randomized blocks. There were four replications only, and therefore the variety comparison was not particularly critical, but there were 24 error degrees of freedom for the seed size comparison, and the varieties $\times$ seed size interaction. Fertilizing was 100 lb. sulphate of ammonia per acre following tobacco that had received 200 lb. "C" mixture (6:18:12) and 200 lb. sulphate of ammonia per acre. The yield data is given in Table IV.

TABLE IV
Contrasting Seed Sizes with Four Maize Varieties
(Yields of grain in lb. per acre)

<i>Treatment</i>			<i>lb. per acre</i>			
Varieties: Mthenga	F.1	..	(LH. No. 7)	7,283	L.S.D.P0.05 = 228	Coefficient of Var. 6.59%
	F.2	..	(" ")	6,431	—	
	Asikari	..	(S.V. " 16)	6,338	P0.01 = 327	
	Mlonda	..	(S.V.)	5,802	—	
Seed Size	S.1		—	6,639*	—	Coefficient of Var. 4.69%
	S.2	.. ..	—	6,577*	L.S.D.P0.05 = 226	
	S.3	.. ..	—	6,337	P0.01 = 306	

There were significant differences between the four variety treatments and the two larger seed sizes yielded significantly more than the smallest size. There were no significant differences in germination or establishment related to seed size, but a series of physical measurements three weeks after germination showed clear differences. Thus:

- (i) length of the plant from upper side of first rootlet to tip of longest leaf;
- (ii) number of leaves;
- (iii) length of longest leaf;
- (iv) width of longest leaf;
- (v) stem thickness at the point of exertion of the lamina of the oldest entire leaf.

All showed significant differences in favour of the two larger seed sizes over the smallest. The visual difference was apparent until shortly before tasselling after which it disappeared. There was at no time any significant interaction between variety and seed size. Conditions for maize growing, both with regard to climate and soil were very good at the site of the experiment, and it seems reasonable to expect that under harder conditions the difference recorded here would have been more marked in the final yield.

8. DISTRICT MAIZE VARIETY OBSERVATIONS

Single replicates of five maize varieties were grown by a large number of African farmers in 1959/60, as they had been in the two previous years. 51 of these observations were carried out successfully to give yield data in the Central Province, 12 in the Northern Province and six in the Southern Province. Yield data is summarized in Table V.

TABLE V
District Maize Variety Observations

(Yields in lb. of grain per acre)

	<i>No. of trials</i>	<i>Growers own seed</i>	<i>Nam- lenga</i>	<i>L.H. No. 2 Master</i>	<i>S.V. Mlonda</i>	<i>S.V. No. 17 Asikari</i>	<i>Least Sig. diff.</i>
Southern Province ..	6	1,658	1,564	1,696	1,806	1,800	not sig. not sig. 246
Northern Province ..	12	1,611	1,948	1,893	2,021	2,065	
Central Province ..	51	2,720	3,048	3,182	3,177	3,366	

The farmers were asked to place the varieties in an order indicating their general preference. No very clear majority opinion emerged from this in the Southern Province. In the Northern Province Namlenga, Mlonda and Asikari were liked best, with Master and their local maizes somewhat behind. In the Central Province Master was the best liked by a fair margin over Namlenga, Mlonda and Asikari, with local maizes left far behind. The performance of S.V. No. 17 is very satisfactory with regard to yield.

9. DISEASE RESISTANCE

Trials to assess the loss of yield of maize through leaf disease were carried out at Chitedze and Makanga. In neither case were significant results obtained.

Maize Agronomy

FERTILIZER TRIAL

1. TIME OF PLANTING WITH NITROGEN

The object of this experiment was to test the proposition that the beneficial effect of early planting is largely due to the release of nitrogen resulting from the wetting of the dry soil with the first rains. Past experiments had shown that late plantings gave no greater response to applied dressings of nitrogen than did early ones, an observation at variance with the above hypothesis. A 4×3 factorial experiment with four replicates was therefore laid out at two sites. Three levels of nitrogen as sulphate of ammonia were applied to the soil just before planting at four different dates, starting with a dry planting before the first rains. A basal dressing of 200 lb. superphosphate was applied before each planting, and prior to that a soil sample was taken and analysed for total nitrogen and mineralizable nitrogen before and after incubation.

TABLE VI
Responses by Maize to dressings of Nitrogen at different times of planting
Variety: Mthenga (Chitedze) and Mlonda (Chitala). Yields: lb./acre grain

Chitedze		Times of planting	Total N.	Mineral N.		N ₀ Nil	N ₁ 200 lb. S/A.	N ₂ 400 lb. S/A.	Mean T.
				before	after				
Soil Type	..	S.C.L. Pre.	.136	30	67	—	—	—	—
pH	..	6.10 T ₁ 23/11	.149	37	67	6,300	6,160	6,440	6,300***
P. p.p.m.	..	9 T ₂ 24/12	.141	57	84	5,980	6,290	5,690	5,990***
K. me. %	..	.43 T ₃ 7/1	.143	6	47	3,780	3,480	3,450	3,570***
		— T ₄ 21/1	.133	23	52	1,870	1,430	1,620	1,640
		—	—		Mean N.	4,480	4,340	4,300	4,370
Coef. Varn.	..	13.4%	—	—	—	—	—	—	—
L.S.D. 5% T	..	490	—	—	—	—	—	—	—
L.S.D. 5% N	..	420	—	—	—	—	—	—	—
L.S.D. 5% NT	..	840	—	—	—	—	—	—	—
Chitala									
Soil Type	..	S.L. Pre.	.095	20	37	—	—	—	—
pH	..	6.10 T ₁ 1/12	.090	21	23	3,300	4,390	4,440	4,050***
P. p.p.m.	..	4 T ₂ 15/12	.092	11	29	3,780	4,830	5,010	4,540***
K. me. %	..	.75 T ₃ 29/12	.093	46	37	2,240	2,660	2,660	2,520**
		— T ₄ 12/1	.079	9	44	1,370	2,010	2,650	2,010
		—	—		Mean N.	2,670	3,470***	3,685***	3,275
Coef. Varn.	..	11.1%	—	—	—	—	—	—	—
L.S.D. 5% T	..	300	—	—	—	—	—	—	—
L.S.D. 5% N	..	270	—	—	—	—	—	—	—
L.S.D. 5% NT	..	520	—	—	—	—	—	—	—

Plant counts and cob counts show that the nitrogen dressings did not significantly affect the stand, but produced more and bigger cobs per plant where a response was obtained. Late planting tends to reduce the plant stand, increase the number of barren plants and decrease the size of the cobs. It is concluded that it is the excellent conditions for germination and establishment at the onset of the rains (warmth, good aeration, and good surface tilth) as much as the liberation of soil nitrogen, that accounts for the benefit of early planting, and/or climate and soil conditions later in the season in relation to the full development of the maize plant.

2. TYPES OF NITROGEN TRIAL

To compare the efficiency of different types of nitrogenous fertilizer for raising maize yields, a $4 \times 2 \times 2$ factorial experiment with three replications (confounded to give six blocks of eight plots plus a control plot in each block) was laid out at four sites. The soil was sampled before planting. One experiment failed, and one of the remaining experiments was not soil sampled. A basal dressing of 200 lb. superphosphate was applied.

TABLE VII
Maize Responses to different types of Nitrogen

Variety: See below

Yields: lb./acre grain

Station				Chitedze	Chitala	Mbawa
Maize Variety				Mthenga	Mlonda	Local
Soil Type	..	..	..	S.C.L.	—	S.C.L.
pH	..	..	..	6.10	—	5.90
Total N. %	..	..	..	.136	—	.061
Control—Nil	..	..	..	5,480	2,310	1,990
40 lb./acre N.	..	..	..	5,820**	3,410***	2,940***
80 lb./acre N.	..	..	..	5,980**	3,870***	3,460***
Applied at planting	..	..	..	5,940	3,560	3,340*
Applied at 30 days	..	..	..	5,860	3,720	3,060
L.S.D. 5%	..	..	..	200	240	280
Sulphate of Ammonia 21% N	..	..	..	6,060	3,650	3,400
Urea 46% N	..	..	..	5,760	3,810*	3,010
Nitramoncal 20.5% N	..	..	..	5,930	3,820*	3,300
Nitrate of Soda 16% N	..	..	..	5,850	3,390	3,190
L.S.D. 5%	..	..	..	290	340	400
Coefficient of Variation	..	..	..	5.5%	11.6%	15.5%
Mean	..	..	..	5,900	3,520	2,870

From these results it would appear that though sulphate of ammonia is on the whole the most efficient source of nitrogen, nitramoncal and urea are not much inferior. Nitrate of soda is not as good as the other three sources, producing smaller cobs. Optimum dressing appears to be around 40 lb. per acre N and this should be applied early in the season.

3. TIME OF APPLICATION OF PHOSPHATE

This experiment was conducted to find out the best time and method of applying phosphatic fertilizer on phosphate deficient soils. A $4 \times 2 \times 2$ factorial with two replications (confounded to give blocks of eight plots with one control in each plot)

was laid out at two sites. Two forms of phosphate, single and triple superphosphate were used at two levels, 38 and 76 lb. P_2O_5 . These dressings were applied either (i) broadcast before ridging, or (ii) in a band in the ridge top before planting, or (iii) as a top dressing in dollops either side of the hill (as with nitrogenous fertilizers), or (iv) as a top dressing, after planting, placed in a hole in the side of the ridge directly beneath the young plant. A basal dressing of 200 lb. sulphate of ammonia was applied to all plots.

TABLE VIII
Effect on Maize of time and method of applying Phosphate
Variety: Mthenga (Chitedze) and Local (Mbawa) Yields: lb./acre grain

Station	Chitedze	Mbawa
Soil Type	S.C.L.	S.C.L.
pH	6.10	5.90
P. p.p.m. (.03N NH_4F + .025N. HCl) ..	6	9
Control	4,730	2,660
38 lb. P_2O_5	4,635	3,430***
76 lb. P_2O_5	5,295***	3,820***
Single Supers	4,815	3,580
Triple Supers	5,115*	3,680
L.S.D. 5%	280	265
Broadcast before ridging	5,060	3,610
Band in ridge top before planting	4,920	3,760
Top dress either side of hill (14 days) ..	4,750	3,740
Top dress under hill (14 days)	5,110	3,410
L.S.D. 5%	400	380
Coefficient of Variation	7.5%	10.0%
Mean	4,930	3,520

From these results it will be seen that there was little difference between the methods of application. It should be noted that the last application was but 14 days after planting. Triple supers, being more readily available, on the whole gave better responses, especially when top dressed after planting. For pre-planting applications, either broadcast or banded, there is little to choose between single and triple supers from the point of view of correcting phosphate deficiency.

4. MAIZE/TOBACCO CORRELATION TRIALS

During the last two years a series of 3×3 NP fertilizer trials have been conducted at Chitedze with blocks split across the middle, half being planted to maize and half to tobacco. The object of the exercise was to see whether there was any correlation between the responses of maize and of tobacco to identical levels of fertilizer on the same site. If there were correlations, it was hoped that it would be possible to calculate the responses to N and P of tobacco grown on the various soils in the area from the results of district maize trials, which are infinitely easier to conduct. An equation of form

$$T_x = T_0 + R(M_x - M_0)$$

was envisaged, T_x and M_x being the yields of tobacco and maize at level x of fertilizer, T_0 and M_0 the unfertilized yields, and R the regression coefficient resulting from significant correlation.

TABLE IX
Correlation between Tobacco and Maize Yields
Yields: lb. acre cured leaf and grain
Variety: Western Tobacco, Mthenga Maize

[illegible]

From the results to date it is concluded that though one may often tell whether or not there will be a worthwhile tobacco response to N or P on a soil type, as a result of conducting maize fertilizer trials thereon, the correlation is not good enough to enable the exact reponse to be calculated.

5. ROUTINE 3×2 NP TRIALS ON STATIONS

These trials are conducted to keep a check on the soil fertility status on experiment stations, and are conducted on fields as they come under maize in the rotation. One experiment was laid out at Chitedze after a four year Rhodes grass ley that had been ploughed early and had grown a catch crop of cowpeas. Three experiments were laid out at Tuchila on the various soil types. These sites also had been under Rhodes grass ley for 4 or 5 years. The interesting result was that at each site there was a marked response to superphosphate, but very little to sulphate of ammonia, a reversal of the situation found up to a few years ago. Soil analysis at both Chitedze and Tuchila confirmed a high level of soil nitrogen and deficient soil phosphate.

6. RESIDUAL TRIALS AT CHITEDZE

(a) *Maize after Burley Tobacco Fertilizer Trial*

On a sandy site, following a 3×3 factorial NP trial with three replications on Burley tobacco, maize gave no residual responses to main effects, but a very significant interaction, showing that residual responses may be obtained where N and P are applied together, or singly at *low* levels.

TABLE X
Residual Effects of Fertilized Burley Tobacco on Maize
Variety: Asikari *Yield: lb./acre grain*

<i>Fertilizer applied</i> 1958/59				<i>Nil</i>	<i>250 lb.</i> <i>supers</i>	<i>500 lb.</i> <i>supers</i>	<i>Mean</i>
Nil	..	..	..	4,515	4,715	4,160	4,460
150 lb. S/Ammonia	..	..	..	4,995**	4,795*	4,395	4,730
300 lb. S/Ammonia	..	..	..	4,520	4,475	5,170***	4,720
Mean	..	..	..	4,680	4,660	4,580	4,640

Coeff. of Varn. .. 8.8% L.S.D. 5% Marginal Means=180
L.S.D. 5% Centre Table =310

(b) *Maize after Dark-Fired Tobacco Fertilizer Trial*

On a sandy clay loam, after a 3×3×3 factorial DNP trial with 1 replication on Western tobacco, there were marked residual responses to dung and superphosphate provided nitrogen had been applied as well. Where N had been applied alone yields were depressed in the following maize crop.

TABLE XI
Residual Effects of Fertilized Western Tobacco on Maize
Variety: Mithenga *Yields: lb./acre grain*

<i>Treatments</i>	<i>N₀—Nil</i>	<i>N₁—250 lb. S/A</i>	<i>N₂—500 lb. S/A</i>	<i>Mean</i>
D ₀ —Nil	4,470	4,180	3,750	4,140
D ₁ —5 tons/acre F.Y.M.	4,330	4,490	4,600	4,470*
D ₂ —10 tons/acre F.Y.M.	4,450	4,470	4,790	4,570**
P ₀ —Nil	4,390	4,310	3,690	4,130
P ₁ —200 lb. supers	4,360	4,030	4,540	4,310
P ₂ —400 lb. supers	4,500	4,800	4,900	4,740***
Mean	4,420	4,380	4,380	4,390
Coef. Varn. 7.0%	L.S.D. 5% Marginal Means			310
	Centre Table			780

(c) Maize after Sweet Potato Fertilizer Trial and Cowpeas

These crops were grown as a catch crop on a Rhodes grass ley ploughed in late January. There were no significant differences either between the fertilizer treatments applied the previous year to the sweet potatoes, or between sweet potatoes and cowpeas as alternative catch crops.

TABLE XII
Residual Effects on Maize of different sorts of catch crops after an early ploughed Rhodes grass ley

<i>Treatment</i>	<i>Yield</i>	<i>Treatment</i>	<i>Yield</i>
N ₀ —Nil	4,130	Mean Yield Mz. after sweet potato fertilizer trial ..	4,260
N ₁ —200 lb. S/A	4,390		
P ₀ —Nil	4,330	Mean Yield Mz. after cowpeas	4,340
P ₁ —200 lb. supers	4,180		
L.S.D. 5%	300	Coefficient of Varn. ..	12.0%

7. RESIDUAL TRIAL ON SULPHUR DEFICIENT SOIL AT MBAWA

At this site, maize was grown after groundnuts which had been dressed with a number of fertilizers, aiming at the correction of a sulphur and/or phosphate deficiency in the soil. Ten treatments had been applied in a 2×5 factorial design with four replications. This season's results with maize closely followed those of last season's groundnut crop.

TABLE XIII
Residual Effects on Maize of Fertilizers applied to Groundnuts

Variety: Local *Yields: lb./acre grain*

	<i>Nil</i>	<i>200 lb. S/A.</i>	<i>100 lb. urea</i>	<i>300 lb. gypsum</i>	<i>Gypsum urea</i>	<i>Mean</i>
Nil	2,465	3,575	2,720	3,635	4,080	3,295
200 lb./acre supers	3,420	3,390	3,630	3,415	3,975	3,565
Mean	2,945	3,480*	3,175	3,525*	4,025***	3,430
Response	+955***	—185	+910***	—220	—105	—

L.S.D. 5% Nil—vs—Supers ..280 Other treats .. 440 Centre table Responses 620

Wherever the fertilizer applied contained sulphur, i.e. sulphate of ammonia, gypsum or superphosphate, large responses were obtained even with maize grown in the year after application. Phosphate alone appears to have little effect on this site, for the single superphosphate gives increases only when no other sulphur containing fertilizer is applied as well. It slightly decreases yields otherwise. Soil analysis showed the phosphate status to be good.

8. GREEN MANURE TRIALS

(a) Federal Green Manure Trials at Chitedze and Tung Station

The object of this series of experiments was to compare the value of green manuring in different parts of the Federation and to compare the relative value of leguminous and non-leguminous green manure with particular reference to nitrogen supply. The design was a 2×3 factorial with split plots and 2 replications confounded to give 4 blocks. The experiments have a 2 year cycle, the two green manures and three methods of disposal being applied to main plots in the first year, and the two levels of P and four levels of N being applied to the sub plots in the second year of maize. Both green manures received a basal dressing of superphosphate and the bulrush millet received 40 lb./acre N as well. There were no control plots of continuous cropping unfortunately, and it is doubtful at Chitedze whether the green manure had any effect on the fertile soil, though at the other site, some benefit is likely.

TABLE XIV

Effects of Green Manure Treatments on Maize Yields

Variety: Mthenga

Yields: lb./acre grain

Treatments/Station						Chitedze	Tung Station
Soil Type	..	..	..	..	..	S.C.L.	S.C.L.
pH	..	..	..	..	..	6.2	5.6
%N at outset	..	..	..	..	..	.169	.155
P. at outset p.p.m.	..	..	..	..	..	40	198
Organic C. at outset	..	..	..	..	..	2.35	1.80
<i>Types of Green Manure</i>							
A.	Sunnhemp	..	..	..	..	5,720	3,210*
B.	Bulrush Millet +40 lb. N	..	..	..	..	5,810	3,000
	L.S.D. 5%	..	..	..	..	370	190
<i>Disposal</i>							
X	Turned in	..	..	..	..	5,850	3,150
Y	Cut and Removed	..	..	..	..	5,830	3,030
Z	Burned on plot	..	..	..	..	5,620	3,140
	L.S.D. 5%	..	..	..	..	450	240
<i>Fertilizers applied to Maize</i>							
P ₀	Nil	..	..	..	..	5,610	3,050
P ₁	200 lb. Supers	..	..	..	..	5,880**	3,150
	L.S.D. 5%	..	..	..	..	180	200
N ₀	Nil	..	..	..	..	5,400	2,770
N ₁	100 lb. S/Ammonia	..	..	..	..	5,625	3,200**
N ₂	200 lb. S/Ammonia	..	..	..	..	5,930***	3,300***
N ₃	400 lb. S/Ammonia	..	..	..	..	6,115***	3,150**
	L.S.D. 5%	..	..	..	..	250	280
Coefficient of Variation						7.4%	15.4%
Mean						5,770	3,100

TABLE XV

Details of Green Material available for turning in at Chitedze

<i>Crop</i>	<i>Date sampled</i>	<i>O.M. tons/acre ft.</i>	<i>N. lb./acre ft.</i>	<i>P₂O₅ lb./acre ft.</i>	<i>K₂O. lb./acre ft.</i>
Sunnhemp tops	20/3/57	3.32	118	23	136
roots		2.00	31	9	—
TOTAL		5.32	149	31	—
Bulrush millet + 40 lb. N. tops ..	2/3/57	4.78	105	22	363
roots ..		.92	14	3	—
TOTAL		5.70	119	25	—

TABLE XVI

Soil Analysis figures following Green Manure Treatments at Chitedze

<i>Treatment</i>	<i>pH</i>	<i>O.M. %</i>	<i>Total N. %</i>	<i>Mineral Nitrogen</i>		<i>Available P. p.p.m.</i>
				<i>before</i>	<i>after</i>	
Sunnhemp AX Buried	6.10	3.72	.151	94	125	11
AY Removed	6.10	3.83	.156	42	60	8
AZ Burned	6.40	4.07	.163	21	53	15
B. Millet BX Buried	6.20	3.97	.157	48	75	10
BY Removed	6.10	4.02	.163	40	76	11
BZ Burned	6.40	3.90	.159	21	56	16

(b) 3×3×3 Factorial at Tuchila

In this experiment three leguminous green manures were planted at three different times and dug in at three different ages to compare the effectiveness of a green manure crop with a groundnut crop as a precursor to maize. There was a single replicate confounded to give three blocks, with one control (groundnut) plot per block.

TABLE XVII

Effect of Green Manuring on Maize at Tuchila

<i>Variety: Namlenga</i>						<i>Yields: lb./acre grain</i>
<i>Treatment</i>						<i>Yield</i>
Control—Groundnuts	..	..	..	..	..	3,270
V ₀ —Sunnhemp	..	..	..	..	..	3,530
V ₁ —Velvet Beans	..	..	..	..	..	3,530
V ₂ —Soya Beans	..	..	..	..	..	3,410
P ₀ —Planted Early December	..	..	..	..	..	3,610*
P ₁ —Planted End December	..	..	..	..	..	3,710*
P ₂ —Planted Mid January	..	..	..	..	..	3,140
D ₀ —Dug in at 2 months old—catch crop beans	..	..	..	..	..	3,300
D ₁ —Dug in at 2 months old—no catch crop	..	..	..	..	..	3,450
D ₂ —Dug in at 3 months old—no catch crop	..	..	..	..	..	3,720
L.S.D. 5%	..	..	..	..	..	380
Coefficient of Variation	..	..	10.0%	Mean ..	..	3,490

It will be seen that maize did not give appreciably greater yields after green manure than after groundnuts. The best green manure plots, i.e. those planted in December and dug in at 3 months old, gave about 4,000 lb. grain against the groundnut plots 3,270 lb.

(c) $2 \times 2 \times 2$ Factorial at Mbawa and Chitala

These experiments were abbreviations of the one quoted above, with their replications confounded to give 6 blocks. Three of the control plots were planted to maize in the first year and three to groundnuts. A maize test crop covered the whole area in the second year.

TABLE XVIII

Effect of Green Manuring on Maize at Mbawa and Chitala

Variety: Local (Mbawa) and Mlonda (Chitala)

Yields: lb./acre grain

Treatment	Mbawa	Chitala
Control (a) Maize	2,160	2,070
Control (b) Groundnuts	3,650***	3,250**
Sunnhemp	3,850***	3,270**
Velvet bean	3,850***	3,100**
Plant early (December)	3,690	3,300
Plant late (January)	4,010	3,070
Dig early (2 months)	3,850	3,260
Dig late (3 months)	3,850	3,110
L.S.D. 5%	480	540
Coefficient of Variation	15.2%	20.1%
Mean	3,680	3,090

These experiments again show that green manures have little more beneficial *short term* effect on maize than groundnuts do on the heavier soils, and that the actual time of planting and digging in of the green manure is not very critical. This confirms past experience in Nyasaland.

9. DISTRICT FERTILIZER TRIALS

(a) *Exploratory Trials on worked out soils in Fort Manning*

These soils have in the past shown very erratic responses to fertilizers and on analysis very low nutrient status. 2^4 factorial experiments were therefore put down to test the responses to nitrogen, phosphate, potash and lime. The design had two replicates and was confounded to give four blocks. Yields were somewhat better this year than in the past, marked responses were obtained to nitrogen and phosphate both alone and combined. There was little response to potash or lime, in spite of the considerable soil acidity.

TABLE XIX

Effects of N, P, K and Ca on Maize in Fort Manning District

Variety: Local

Yields: lb./acre grain

Treatment						Namizana	Kochira
Soil Type	..	..	..	..	..	S.C.L.	S.C.L.
Total N. %	..	..	..	..	..	.094	.088
Available P. p.p.m.	..	..	..	..	..	6	8
K. me. %	..	..	..	..	..	.18	.19
Organic Carbon	..	..	..	..	..	0.95	0.87
pH	..	..	..	..	..	5.50	5.40
N ₀ —Nil	..	..	..	..	..	2,510	1,670
N ₁ —200 lb. S/Ammonia	..	..	..	..	..	3,010*	2,590***
P ₀ —Nil	..	..	..	..	..	2,040	2,000
P ₁ —200 lb. Supers	..	..	..	..	..	3,480***	2,260
K ₀ —Nil	..	..	..	..	..	2,770	2,160
K ₁ —50 lb. KCl	..	..	..	..	..	2,760	2,080
Ca ₀ —Nil	..	..	..	..	..	2,610	2,090
Ca ₁ —1,000 lb. Lime	..	..	..	..	..	2,920	2,170
L.S.D. 5%	..	..	..	..	..	430	270
Coefficient of Variation	..	..	..	..	..	20.7%	16.7%
Mean	..	..	..	..	..	2,760	2,130
Interactions Significant	..	..	..	..	..	None	NP, NK.

(b) Nitrogen and Population Trial on Kasungu Sand

On these poor soils, yields are low, and large responses are obtained from sulphate of ammonia though not from superphosphate. It was thought that the inherent fertility of these soils might be insufficient to carry a crop of 14,500 plants per acre. This experiment was a 3×3 factorial combining three levels of nitrogen with three populations, the highest being the standard 14,500 plants per acre. There were three replications.

TABLE XX

Effects of Nitrogen and Population on Maize in Kasungu

Variety: Local

Yields: lb./acre grain

Treatment					Yield	Plants/ acre	Cobs/ acre	Barren plants	lb. per cob
N ₀ —Nil	..	..	..	..	910	9,000	5,500	3,500	.163
N ₁ —100 lb. S/Ammonia	..	..	..	..	1,550***	9,200	7,500	1,700	.208
N ₂ —200 lb. S/Ammonia	..	..	..	..	1,900***	9,000	8,000	1,000	.237
S ₀ —3×3×3 (14,520)	..	..	..	..	1,640*	13,000	8,900	4,100	.185
S ₁ —3×3×2 (9,680)	..	..	..	..	1,450	9,400	7,500	1,900	.197
S ₂ —3×3×1 (4,840)	..	..	..	..	1,270	4,800	4,800	—	.265
L.S.D. 5%	..	..	..	..	270	—	—	—	—

Coefficient of Variation

..

..

18.4%

Mean

..

1,450

There was the expected large response to nitrogen which increases the size of the cobs and reduces the number of barren plants. Though there was this year no significant interaction between nitrogen and spacing, the indication remains that where fertilizer can be applied or the fertility is fair, the full 14,500 plants should be

planted for maximum yield. The 9,680 plant stand gives a yield not significantly less over all fertilizer treatments, and it does appear to yield more than the higher population when no fertilizer is applied. Though the lowest population produced the biggest cobs and no barren plants, the number is insufficient for maximum yield potential, especially where fertilizer is applied. One should aim, on these soils, at a population between 10,000 and 14,000 plants per acre, depending on the fertility of the soil.

(c) *District Fertilizer Trials*

In the 1959/60 season 18 trials of various design were conducted in Central Province, 13 trials in Northern Province and 8 trials in Southern Province. As a result of considering all district trials conducted to date, it is now possible to make a preliminary map delimiting zones with characteristic fertilizer responses. A map of Nyasaland showing these is appended.

The following six main characters have been picked out:

- (a) Soils giving no response to either N or P.
- (b) Soils responding to nitrogen.
- (c) Soils definitely deficient in P and always giving a response.
- (d) Soils showing low phosphate status on analysis, but giving little response to fertilizer P.
- (e) Soils which often show an adequate phosphate status on analysis, but which sometimes respond to fertilizer P.
- (f) Soils showing sulphur deficiency.

The whole territory except certain alluvial soils will usually prove deficient in nitrogen. Some acid hill soils, such as those of the Misuku, will also show no response to applied nitrogen. The definitely phosphate deficient soils are found in Northern Province between the hills edging the rift valley and the Northern Rhodesian border, and they stretch approximately to the line of the Dwangwa River in Kasungu in the south. Other areas of potential phosphate shortage include the poor soils of South Kasungu and Fort Manning and the hill soils and neighbourhood of the Dzalanyama, Dowa, North Kirk and Namwera ranges. Sulphur deficiency marches with phosphate deficiency in the South Rukuru and Kasitu River catchment areas.

There is considerable correlation between fertilizer response zones and the soil types as mapped by Dr. A. Young in the Central and Northern Provinces. In the Southern Province, where the coverage of trials has left certain gaps, the following four zones, marked with a ? on the map, have been put in as a result of reference to Dr. Young's soil map, there being insufficient agronomic evidence to confirm them.

- (1) North Kirk and Ncheu Hills.
- (2) Namwera Hills.
- (3) East Malombe plain.
- (4) Chilwa/Chiuta/Palombe plain.

This map refers to unimproved farm-land, and is designed to aid officers who have to advise farmers embarking upon improved rotation and the use of fertilizers. Where a farmer has already adopted a system of intensive farming, and especially if he has been regularly applying farmyard manure, his land may diverge from the expected patterns, and intelligent use of observation plots and soil sampling will be needed to keep track of his fertilizer requirements.

Cultivation Trials

1. METHOD OF PLANTING TRIAL (BAKA, KARONGA)

This experiment was laid out to test the assertion by the local inhabitants that maize planted on ridges would suffer from drought and yield much less well than maize planted on the flat. The design was a simple randomized block with six replications. The three treatments were: (i) flat planting, (ii) ridge planting and (iii) flat planting followed by ridging up when the maize was 6 inches high. All plots were spaced 3 feet $\times$ 3 feet $\times$ 3 plants.

TABLE XXI

Effect of Method of Planting on Maize Yields in Karonga

Variety: Local

Yields: lb./acre cob wt.

<i>Treatment</i>	<i>Yield/acre</i>	<i>No. of plants/acre</i>
1. Flat Planted	2,510	10,000
2. Ridge Planted	2,350	9,800
3. Flat Planted then Ridged	2,480	10,100

L.S.D. 5% .. 400 Coef. of Varn. .. 12.5% Mean 2,450

As rainfall in December and January was below average, this was a fairly good test of the hypothesis, and at the end of January the ridge cultivated maize did look poorer. However the plants grew away in February and March and resulted in no differences in visible vigour or yield at harvest.

2. STEM BORER CONTROL AT NCHENACHENA

At the higher altitude and on poorer soils, considerable loss to the maize crop results from attack by stem borer *Busseola fusca*. Past experience indicates that the attack can be easily and economically controlled by shaking D.D.T. dust into the funnels of the young plants when they are about 18 inches high. This year's experiment in the series was a 4 $\times$ 2 factorial with four replications, four dusting treatments being combined with presence and absence of nitrogen. There was no response to nitrogen and all dusting treatments increased yield by about the same amount.

TABLE XXII

Effect of D.D.T. Dust on Control of Stem Borer and on Maize Yields

Variety: Local

Yields: lb./acre grain

<i>Treatment</i>	<i>Yield</i>	<i>Visibly damaged plants per acre</i>	<i>per cent. attack</i>
(a) No treatment	3,350	12,190	88
(b) 5 lb. 5% D.D.T./acre. 1 application	4,630	4,620	33
(c) 10 lb. 5% D.D.T./acre. 1 application	4,665	2,880	21
(d) 10 lb. 5% D.D.T./acre. 2 applications	4,855	520	4
L.S.D. 5%	380		—
N ₀ —Nil	4,290	5,140	37
N ₁ —200 lb. per acre S/Ammonia	4,455	4,970	36
L.S.D. 5%	265	—	—

Coefficient of Variation 8.9% Mean .. 4,375

It may thus be seen that the most economic dressing from the point of view of short term raising of yield is one application of 5 lb. of 5 per cent. D.D.T. dust (in this case on 29th December). If long term control over a wide area is envisaged, then it is well worthwhile repeating the application a fortnight later. Past experiments corroborate this.

3. CULTIVATION TRIALS

(a) The October preparation of gardens experiments at Chitedze and Tuchila after having the same treatments reapplied for three or four seasons show that ridges should be split rather than made up on their old alignment, when cultivated by hand. Burying or burning the stover and trash are equally effective in maintaining yields on the heavier soils, and both are preferable to leaving the stover as a surface mulch or carting it off, unless, in the latter case, it can be returned as farmyard manure.

(b) A piece of land at Chitedze under continuous maize and a minimum of cultivation for four years had half its area ploughed, and the rest received minimum clearance of weeds by hand hoe. Each area was split for nil and 200 lb. per acre sulphate of ammonia, top dressed on the maize. Ploughing did increase the yield, but nitrogen application completely masked the effect.

TABLE XXIII
Effect of Ploughing and N on old Maize Land

Variety: Namlenga					Yields: lb./acre grain		
					Ploughed	Not ploughed	Mean
Nil	..	..	..	..	2,790	2,190	2,490
200 lb. S/Ammonia	..	..	..	..	3,160	3,440	3,300
Mean	..	..	..	..	2,975	2,815	2,895

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

EFFECT OF NITROGEN ON MONTMORILLONITIC CLAY SOILS

The introduction of the Mlonda variety of maize has led to rather higher levels of yields—but the composition trials on sandy and clay soils were not extended this year. However a pot trial was carried out at the higher altitude (3,800 feet) of Bvumbwe and Makanga (150 feet) to compare the effect of climate on maize growth and response to nitrogen on three different types of soils. Assessment was made by weight of green matter, and its nitrogen content, the results being summarized below:

Soil Type				N. Equiv. to S/A lb./acre	Green Matter (grms)		Nitrogen %†	Nitrogen mg.†*
					Makanga	Bvumbwe	(Bvumbwe only)	
Makanga Clay	..	..	{	0	27	20	1.14	228
pH 7.3	..	..		200	97	86	3.98	3,423
N 0.10%	..	..		400	96	37	4.45	1,647
				600	79	—	—	—
Nsua Island	..	..	{	0	97	10	1.16	232
Clay Loam	..	..		200	97	48	3.95	1,900
pH 7.1	..	..		400	72	41	4.58	4,400
N 0.18%	..	..		600	61	41	4.91	2,010
				800	38	8	—	—
Nsua Island	..	..	{	0	37	9	0.91	83
Clay	..	..		200	110	47	3.55	1,670
pH 6.5	..	..		400	75	20	4.20	840
N 0.27%	..	..		600	57	19	4.65	885
				800	43	—	—	—

† dry weight basis * leaf weight basis.

At Makanga, germination proved good; at Bvumbwe, rates equivalent to 600, 800 or 1,000 lb./acre S/A prevented or impaired germination. At Bvumbwe, all controls exhibited retarded growth, chlorosis, necrotic margins and phosphate deficiency symptoms. Such symptoms were not so apparent at Makanga, except in the case of the Makanga Clay.

The immediate conclusion is that a rate of application of 200 lb./acre S/A proves efficacious. On the Nsua Island Clay Loam, 400 lb./acre also proved effective (at Bvumbwe only). Applications at levels higher than 200 lb./acre on the Makanga Clay and the Nsua Island Clay depress yields; in the case of the Nsua Island Clay Loam, applications greater than 400 lb./acre have this effect (again, at Bvumbwe only). The control pots generally showed poorer growth and, in certain cases, showed both nitrogen and phosphate deficiency symptoms. The plants grown at Makanga exhibited better growth throughout and there were no deaths even at the highest fertilizer application levels. But the general trend, as referred to above, is reasonably consistent at both Bvumbwe and Makanga and is exhibited both in green matter weights and actual nitrogen uptake. It is interesting that the plant uptake of nitrogen follows the nitrogen application. It should be mentioned that such increases obtained in this trial do not necessarily indicate any potential improvement in cob yields.

Extract from Report of the Plant Pathologist

The most serious disease of maize during the year was the complex of diseases causing cob rots. *Fusarium moniliforme* Ssensu Sn. & Hans, *F. graminearum* Schw and *Nigrispora oryzae* (B. & Br.) Petch appeared to be the commonest from the few observations made. The wet weather during the period when the cobs were forming undoubtedly was responsible for much of this.

OTHER CEREALS

Sorghums

A new beer variety K₂ introduced from the Union of South Africa failed to produce a crop at Chitedze, though it produced the poor yield of 580 lb. per acre good seed at Chitala. At both sites it was late planted.

Finger Millet

1. TRIAL ON ALTERNATIVES TO "VISOSO" CULTIVATION AT MBAWA

The traditional way of growing finger millet in the Northern Province is to cut a large area of woodland, burn the timber on a small part of the poor sandy soils so cleared and to broadcast finger millet on the flat among the ashes. This is wasteful of timber and impracticable in a settled agricultural system. In a 4×3 factorial experiment with four replications, the *visoso* method was compared with growing the crop on second year land after maize with and without farmyard manure and after groundnuts, three levels of nitrogen being applied to the millet. There was no significant difference between the *visoso* and the other methods of cultivation, and the expected large response to nitrogen was obtained.

TABLE I
Effect of Nitrogen and previous cropping on Finger Millet

Variety: Local

Yields: lb./acre grain

Previous Treatment	Yield	Fertilizer	Yield
<i>Visoso</i> —bush burned	1,370	N ₀ — Nil	1,170
Maize—5 tons per acre F.Y.M. ..	1,490	N ₁ — 100 lb. S/A	1,390***
Maize—no fertilizer	1,320	N ₂ — 200 lb. S/A	1,520***
Groundnuts	1,260	L.S.D. 5%	110
L.S.D. 5%	190		
Coefficient of Variation	11.6%	Mean	1,320

2. METHOD OF PLANTING TRIAL AT BAKA, KARONGA

A 3×2 factorial trial with eight replications was laid out at Karonga to test three methods of planting at two times of planting. December planting gave much better yields than February planting, and drilling the seed in rows 18 inches apart on the flat gave better yields than broadcasting on the flat or planting two rows of hills per 3 feet ridge. Planting at the end of December combined high yield with optimum conditions for weed control.

TABLE II
Effects of time and method of planting on Finger Millet
Variety: Local *Yields: lb./acre heads*

<i>Time of planting</i>	<i>Yield</i>	<i>Method of planting</i>	<i>Yield</i>
December planting ..	1,610***	Broadcast on flat	1,320
February planting ..	1,055	18 in. drills on flat	1,545***
		Ridge cultivation	1,130
L.S.D. 5% ..	165	L.S.D. 5%	200
Coefficient of Variation ..	21.1%	Mean	1,330

3. DISTRICT FERTILIZER TRIALS

Three trials were conducted in the Karonga and Rumpi Districts of 3×2 or $3 \times 2 \times 2$ design, testing three levels of nitrogen with two levels of phosphate and/or two times of planting. Large responses were obtained to nitrogen, phosphate and time of planting.

TABLE III
Finger Millet responses to N, P and Time of Planting
Variety: Local *Yields: lb./acre heads or grain*

<i>Treatment/Place</i>	<i>Baka (Ka)</i>	<i>Mfinda (Ka)</i>	<i>Luwiri (Ru)</i>
Soil Type	S.C.L.	L.S.	L.S.
pH	6.40	5.75	6.25
Total N%	.128	.050	.092
Available P. p.p.m.	48	16	11
Early Planted	1,830***	—	1,970
Late Planted	1,250	—	1,480
L.S.D. 5%	170	—	—
N ₀ — Nil	1,325	1,290	1,640
N ₁ — 100 lb. S/Ammonia	1,600**	1,460	1,720
N ₂ — 200 lb. S/Ammonia	1,770***	1,750*	2,050
L.S.D. 5%	180	330	—
P ₀ — Nil	—	1,260	1,530
P ₁ — 400 lb. Supers	—	1,740**	2,070
L.S.D. 5%	—	275	—
Coefficient of Variation	15.8%	20.8%	Not analysable
Mean	1,500 lb. heads	1,500 lb. grain	—

Good yields of finger millet can be obtained by planting at the end of December or early January and applying up to 200 lb. per acre each of ammonium sulphate and superphosphate.

Rice

1. CULTIVATION TRIAL AT MWENETETE, KARONGA

A $3 \times 2 \times 2$ factorial trial with four replications was laid down in the rice growing area of Mwenetete, to test three methods of planting in combination with early and late ploughing and early and late planting. Past experience has indicated that rice yields are closely and inversely correlated with weed infestation, and the

experiment aimed at finding the best way of controlling weeds. It appears that best weed control and consequently the highest yields are obtained by ploughing immediately after harvest, and sowing or transplanting at the beginning of February. The traditional system of waiting until after the first rains before ploughing gives minimum control of weeds unless planting is delayed until too late in the season. Sowing of pregerminated seed gave better results than sowing of dry seed, though at the optimum planting time, early February, transplants gave the highest yield.

TABLE IV
Effects of Cultivation and Planting methods on Rice yields
Variety: Faya *Yields: lb./acre paddy*

<i>Treatment</i>				<i>Yield</i>	<i>Treatment</i>		<i>Yield</i>
1st ploughing after harvest	..	..	..	1,490**	Dry seed		1,290
1st ploughing after 1st rains	..	..	..	1,150	Pregerminated seed		1,480*
					Transplants		1,190
Plant early January	..	..	..	1,140			
Plant early February	..	..	..	1,500**			
L.S.D. 5%	..	..	..	220	L.S.D. 5%		270
Coefficient of Variation	..	..	..	28.5%	Mean		1,320

2. FERTILIZER TRIAL AT MWENETETE, KARONGA

In a 3×3 factorial with two replications, the response of rice to nitrogenous fertilizer was measured by applying three levels of sulphate of ammonia to the seedbed in all combinations with three levels top dressed in mid February. There were significant responses to applications at both times, though the late application was rather more effective, due possibly to fast moving floods washing away the fertilizer applied to the seedbed. Effects were additive, though there is an indication that a total of 600 lb. per acre sulphate of ammonia is as much as it is advisable to apply.

TABLE V
Rice responses to Nitrogenous fertilizer
Variety: Faya *Yields: lb./acre paddy*

<i>Applied to seedbed, 1st Jan.</i>				<i>Yield</i>	<i>Top Dressed, 17th Feb.</i>		<i>Yield</i>
A ₀ — Nil	..	..	..	1,900	B ₀ — Nil		1,775
A ₁ — 200 lb. S/Ammonia	..	..	..	2,460**	B ₁ — 200 lb. S/Ammonia		2,240***
A ₂ — 400 lb. S/Ammonia	..	..	..	2,380**	B ₂ — 400 lb. S/Ammonia		2,735***
L.S.D. 5%	..	..	..	275	L.S.D. 5%		275
Coefficient of Variation	..	..	..	9.2%	Mean		2,250

OIL SEEDS

Groundnut Variety Trials

1. GROUNDNUT VARIETY TRIAL, CHITEDZE

In a 5×5 lattice square design with three replications, recently imported varieties were compared with the standard varieties Mwitunde, Dixie Runner, Early Runner, Gambia and A.R.S. Spanish, together with a number of varieties from the collection chosen for medium sized nuts in large shells, a factor which helps to make shelling easier. The late varieties again yielded better as a group at Chitedze than the early ones. Outstanding among the introductions were the red and white flecked varieties Amani and Mani Pintar, the former having an exceptionally large nut though very moderate oil content, and the latter producing large well filled nuts of good oil content, an excellent sample to see. Of the varieties exhibiting some degree of resistance to *Cercospora* leaf spot, Konyoma yielded more than the standards and Mwitunde ex Nachingwea gave over 1,000 lb. per acre. Two Chalimbana type nuts Buyaya and Karonga also gave yields above average. Of the easy shelling varieties, U/A 34 gave the best yields, though when it came to machine shelling with hand Skylux machines of present design, it gave as high a percentage of broken and damaged nuts as any other variety of comparable size (35 per cent.). Small Virginia type nuts such as Natal Common, Gambia and A.R.S. Spanish can be shelled by existing machinery with as little as 10 per cent. broken and damaged nuts, but the larger the nut the more easily is it damaged and even adjustable machines have not large enough clearances yet between the beater bars and the screen.

TABLE I

Results of testing of new Groundnut Varieties at Chitedze

Variety: Various

Yields: lb./acre shelled

<i>Variety</i>	<i>Type</i>	<i>Yield</i>	<i>No. of seeds per lb.</i>	<i>Oil Content (per cent. dry kernel)</i>	<i>Cercospora infection Count</i>
Amani	LR	1,530	565**	47.6	255
Mani Pintar	LB	1,410	775*	49.5†	285
Konyoma	LR	1,300	890*	51.3†	154†
Dixie Runner	LR	1,270	1,100	49.5†	189†
Mwitunde	LB	1,250	910	51.0†	172†
U/A 34	LR	1,220	945	50.2†	187†
Early Runner	MR	1,140	1,020	47.4	472
Buyaya	LR	1,120	635**	46.3	291
S. Rhodesian II	LR	1,040	940	48.2	256
S. Rhodesian III	LR	1,020	930	48.8	206
Mwitunde ex Nachingwea	LB	1,020	1,020	52.0†	146†
Karonga	LR	1,000	600**	47.2	342
T/A 2	LR	850	860*	49.3†	178†
Gambia	EB	800	1,730	45.8	547
Rumpi Black	EB	800	1,210	48.7	687

TABLE I—(Continued)

Variety	Type	Yield	No. of seeds per lb.	Oil Content (per cent. dry kernel)	Cercospora infection Count
Skylux A	EB	790	1,270	47.3	905
S. Rhodesian I	EB	790	1,420	47.7	803
A.R.S. Spanish	EB	780	1,320	48.5	736
Mahogany	EB	750	1,260	47.5	715
S. Rhodesian IV	EB	700	1,460	46.3	732
Kabota	EB	690	1,430	46.1	707
N/A 3a	LB	660	670*	46.3	218
H.G.1.	LB	630	1,030	46.9	459
Skylux B.	LB	630	740*	45.1	168‡
Valencia Israel	LB	610	710*	46.4	201

L.S.D. 5%

130

Coefficient of Variation 7.4%

* Nuts larger than Mwitunde

** Nuts of Chalimbana size.

† Over 49.0 per cent. oil.

‡ Displaying more than average resistance to *Cercospora* leaf spot.

Standard varieties in bold type.

E=Early

M=Medium

L=Late maturing

B=Bunch

R=Runner habit.

DISTRICT VARIETY TRIALS IN NORTHERN PROVINCE

These trials were conducted to find out which was the best groundnut variety for each of the main agronomic areas. The trials were of Latin square design in all except one experiment. At Baka the trial was a randomized block design.

TABLE II
Results of District Variety Trials in Northern Province

Yields: lb./acre shelled nuts

Variety: Various

Variety	Type	Lake-shore plain			Misuku		Nyika foothills, Rumpi		South West Mzimba	
		Baka	Lupembe	Deep Bay	Katobo	Katowo	Pharasiwe	Nchenachena	Jenda	Kacheche
Gambia ..	..	1,595***	1,625	2,005***	760*	—	—	—	—	—
Spanish ..	..	985	—	—	—	220	480	760*	215	130
Mwitunde ..	..	900	1,500	1,210	350	415	705	480	475*	550
Dixie Runner ..	..	1,360***	1,675	1,485*	—	800*	865	690*	750***	410
Local ..	..	795	1,605	1,103	320	660	485	630	675***	355
Chalimbana ..	..	—	—	1,335	445	—	—	—	560**	—
Early Runner ..	..	1,355***	—	—	—	—	—	—	—	—
A.M. 2 ..	..	1,070*	—	—	—	—	—	—	—	—
L.S.D. 5 % ..	..	200	None	365	245	209	None	170	190	110
Coef. of Varn. ..	..	13.5%	13.6%	18.5%	30.5%	39.4%	29.0%	15.2%	25.7%	17.1%
Mean ..	..	1,150	1,600	1,425	470	525	685	640	535	360

These results tend to confirm previous impressions that on the Lake-shore and in the higher hills (Katobo and Nchenya) the early maturing varieties do best, though it will be seen that Dixie Runner is very adaptable and also does well at these sites. In the lower parts of Rumpi and in the Mzimba valleys and foot hills, late maturing varieties do best. Dixie Runner has at each site outyielded Mwitunde, and with its greater adaptability, it may well replace Mwitunde as the recommended variety for Northern Province after another year's testing. Except on the Karonga Lake-shore, yields are miserably low, underlining the sulphur and phosphate deficiency of these soils.

Groundnut Fertilizer Trials

1. FERTILIZER TRIALS, CENTRAL PROVINCE

At Chitedze groundnuts grown on the sites of two 3×2 factorial NP trials fertilized and planted to maize in the previous year, gave a significant residual response (of 130 lb. nuts) to 200 lb. per acre superphosphate on one site only. There were no residual responses to sulphate of ammonia or muriate of potash applied to two out of the four replications. Yields were fair to good, means being 1,080 and 1,200 lb. per acre shelled nuts.

2. FERTILIZER TRIALS, NORTHERN PROVINCE

(a) *Residual phosphate trial, Mbawa*

On a very phosphate deficient soil at Mbawa, a randomized block experiment with four replications and containing five phosphate treatments and a nil control was conducted with maize as the test crop in 1958/59. Last season groundnuts sown to test the residual effects of the treatments showed large responses, especially to a 200 lb. dressing of single superphosphate. The whole area had a basal dressing of 200 lb. per acre sulphate of ammonia applied to the maize.

TABLE III
Residual Effects of Phosphatic Fertilizers on Groundnuts

Variety: <i>Mwitunde</i>						Yields: lb./acre shelled nuts
Treatments						Yields
Nil	..	..	..	..	..	534
200 lb. raw rock phosphate	..	..	..	..	..	548
400 lb. raw rock phosphate	..	..	..	..	..	609*
200 lb. single superphosphate	..	..	..	..	..	776***
85 lb. triple superphosphate	..	..	..	..	..	741**
200 lb. 25/10/0 mixture	..	..	..	..	..	622
Mean	..	..	..	..	..	639
Coefficient of Variation 7.8%						
L.S.D. 5 %						75

(b) *Residual phosphate trial, Rumpi*

On the site of a previous 3×2 factorial NP trial on maize at Luviri, Rumpi, groundnuts gave a significant response (of 200 lb. nuts) to the residual effects of a 200 lb. per acre dressing of superphosphate. There was no residual response to sulphate of ammonia.

(c) *Fertilizer trial on acid soil, Misuku*

In a Latin square design at Katobo, Misuku, there was no significant difference between the four treatments, Nil, 100 lb. per acre gypsum, 100 lb. per acre nitrate of soda and $7\frac{1}{2}$ tons of lime. Yields, on a newly opened site, were very good for the area, being about 1,160 lb. per acre shelled nuts (cf. the results of the variety trial on land which had been under cultivation for much longer).

(d) *Exploratory Fertilizer trials for S, N and P deficiency*

These experiments were of a 2×4 factorial design with three replications, the presence or absence of gypsum being combined with presence or absence of single superphosphate, triple superphosphate and urea.

TABLE IV
Results of Exploratory Groundnut Fertilizer trials

Variety: Local

Yields: lb./acre shelled nuts

Treatment	Zones and Place	Karonga Hills		Rumpi	South Mzimba	W. Vipya Foot-hills	Kasitu V.
		Nkangwa	Mfinda	Ng'onga	Katete	Jendalala	Zombwe
Soil Type	..	S.L.	L.S.	L.S.	S.C.L.	S.C.L.	S.L.
pH	..	6.3	6.2	6.6	5.7	5.7	6.6
Total N. %	..	.117	.048	.067	.070	.077	.062
Available P. p.p.m. ..	..	1	13	13	41	25	18
O—Nil	..	650	970	550	675	1,280	1,140
G—200 lb. Gypsum ..	..	645	1,045	715**	675	1,310	1,100
L.S.D. 5 %	..	105	140	100	None	None	None
O—Nil	..	620	825	475	705	1,285	1,215
S—250 lb. Supers ..	..	690	1,150*	750***	645	1,400	1,100
T—100 lb. Triple ..	..	605	1,085*	640**	670	1,225	1,125
N—100 lb. Urea ..	..	680	975	660**	680	1,285	1,045
L.S.D. 5 %	..	150	200	145	None	None	None
Coefficient of Varn. ..	..	18.7%	15.9%	18.5%	15.0%	17.0%	19.8%
Mean	..	650	1,005	635	675	1,300	1,120
Response Phosphate ..	..	Nil	*	**	Nil	Nil	Nil
Response Sulphur ..	..	Nil	Nil	***	Nil	Nil	Nil
Response Nitrogen ..	..	Nil	Nil	**	Nil	Nil	Nil

These results show marked responses to fertilizer only at Ng'onga and Mfinda, though the absence of response to phosphate at Nkangwa is surprising. At Katete, some factor other than plant food appears to be limiting—pH is low, but no lower than at Jendalala where yields are twice as great.

(e) *Fertilizer trials in areas known to be deficient in S and P*

These trials were randomized blocks with three replications testing two levels of gypsum, single superphosphate and triple superphosphate against a Nil control. Known sulphur and phosphate deficient areas are included in the South Rukuru and Lower Kasitu Valleys and in the Phazi area of South Mzimba.

TABLE V
Groundnut responses to Gypsum and Phosphate
Variety: Local *Yields: lb./acre shelled nuts*

<i>Treatment</i>	<i>Zone and Place</i>	<i>Lower Kasitu</i>	<i>South Rukuru</i>		
		<i>Madise</i>	<i>Njinji</i>	<i>Kamuanga</i>	<i>Kapando</i>
Soil Type		L.S.	S.L.	S.L.	S.L.
pH		6.0	6.5	5.6	6.8
Total N. %		.040	.065	.041	.072
Available P. p.p.m.		10	35	6	9
Nil		600	710	475	510
200 lb. Gypsum		815	1,310**	385	900***
400 lb. Gypsum		—	1,130*	385	890***
250 lb. Supers		—	1,520***	590	800***
500 lb. Supers		—	1,315**	590	885***
100 lb. Triple		815	825	820*	550
200 lb. Triple		—	1,050	565	840***
L.S.D. 5 %		—	405	120	150
Coefficient of Varn.		—	20.2%	18.5%	14.5%
Mean		—	1,190	505	810
Response Phosphate		*?	*	*	*
Response Sulphur		*?	**	Nil	***
Response P+S		—	***	Nil	Nil

It would appear that on these soils single superphosphate is probably the safest fertilizer to use, at about 200 lb. per acre, though gypsum may be equally effective when used also at about 200 lb. per acre. Further trials on optimum levels are needed and planned. On some soils pH well below 6.0 may lead to nutrient unbalance.

(f) Fertilizer trials on soils giving "pops"

These trials of randomized block design with three replications were designed to try to correct nutrient unbalance in soils giving a large proportion of "pops".

TABLE VI
Results of Groundnut "Pops" trials
Variety: Local *Yields: lb./acre shelled nuts*

<i>Treatment</i>	<i>Zone and Place</i>	<i>Phazi area</i>	<i>W. Mzimba</i>
		<i>Kamando</i>	<i>Manyamula</i>
Soil Type		L.S.	L.S.
pH		7.55	6.40
Total N. %		.054	.056
Available P. p.p.m.		71	23
K. me%		.28	.38
Ca. me%		8.1	1.6
Mg. me%		1.2	0.6
Nil		570	235
100 lb. Lime (Ca)		525	540**
200 lb. Gypsum (Ca+S)		725**	315
80 lb. Magnesite (Mg)		545	445*
150 lb. Supers (Ca+S+P)		635*	645***
60 lb. Triple (Ca+P)		575	400
50 lb. KCl. (K+Cl.)		515	305
Triple+KCl. (Ca+P+K+Cl.)		805***	565**
L.S.D. 5 %		140	165
Coefficient of Variation		12.6%	16.1%
Mean		610	445

Though in neither of the experiments was the percentage of " pops " significantly decreased by any treatment, single superphosphate and triple plus muriate of potash both increased yields at both sites. The position is still obscure though a 200 lb. per acre dressing of single superphosphate will markedly increase yields on " pop " prone soil.

Groundnut Cultivation Trials

1. POPULATION TRIAL

A $4 \times 2 \times 2 \times 2$ factorial with one replication confounded to give four blocks was laid out at four sites to check on the recommended spacing of groundnuts. At one of the sites rosette disease caused a complete failure.

Four varieties were planted with one or two rows per ridge, one or two seeds per hill and 9 inches or 12 inches in the row.

TABLE VII
Spacing and Population of Groundnuts

Varieties: See below

Yields: lb./acre shelled nuts

<i>Treatment</i>					<i>Mbawa</i>	<i>Chitala</i>	<i>Chitedze</i>
A.R.S. Spanish or Gambia	..	..	..	BE	1,220	1,105	780
Mwitunde	..	..	..	BL	1,260	1,930***	1,230***
Early Runner	..	..	..	RM	1,190	1,875***	940
Dixie Runner	..	..	..	RL	1,770***	1,830***	1,420***
L.S.D. 5 %	..	..	..		140	165	250
1 row per ridge	..	..	..	..	1,230	1,580	1,000
2 rows per ridge	..	..	..	..	1,490***	1,800***	1,190*
9 inches in row	..	..	..	..	1,390	1,660	1,070
12 inches in row	..	..	..	..	1,330	1,715	1,120
1 seed per hole	..	..	..	..	1,300	1,550	1,070
2 seeds per hole	..	..	..	..	1,420*	1,825***	1,120
L.S.D. 5 %	..	..	..	..	100	115	175
Coefficient of Variation	..	..	..	..	9.3%	8.7%	20.5%
Mean	..	..	..	..	1,360	1,690	1,100

The value of planting two rows per ridge is confirmed, as is that of planting two seeds per hole, unless a really good seed sample is ensured. Spacing between plants in the row is less critical and can be left at 12 inches for the spreading and larger bunch varieties such as Mwitunde and 9 inches for small bunch varieties such as Gambia. The superior yielding power of Dixie Runner is again shown at Chitedze and Mbawa.

2. TIME AND METHOD OF CULTIVATION AT CHITEDZE

This experiment, a 3×3 factorial with four replications, was a repeat on the same site of the treatments applied last year to the maize crop. It shows once again and for groundnuts this time, the value of splitting the ridges in hand cultivation, and it shows that the time of cultivation is immaterial in its effect on yield. From the point of view of weed control and ease of task, cultivation would be best done early in June, if a whole village could be induced to do it together, and if wandering cattle could be kept out.

TABLE VIII
Effect of time and method of cultivation on Groundnuts

Variety: Mwitunde

Yields: lb./acre shelled nuts

<i>Treatment</i>	<i>Yield</i>	<i>Treatment</i>	<i>Yield</i>
Cultivate 28th May	2,500	Make up old ridges	2,270
Cultivate 13th October	2,450	Split ridges	2,500*
Cultivate 5th November (after first rains)	2,330	Dig in the furrow then split ridges	2,500*
L.S.D. 5%	210		
Coeff. Varn.	10.1%		
Mean	2,420		

3. OX, TRACTOR AND HAND CULTIVATION OF GROUNDNUTS AT CHITEDZE

This experiment applies to the preplanting cultivations only, and is a continuation of a 3×2 factorial experiment with three replications, the treatments of which were first applied to the previous maize crop. The land was ploughed by ox or tractor or hand cultivated either shortly after harvest or at the end of the dry season. Owing to inadequate harrowing equipment, the ox ploughed plots were rather rough and this may have been the cause of lower yields. There was no difference between early and late cultivation as far as yield was concerned.

TABLE IX
Effects of hand, ox and tractor cultivation on Groundnuts

Variety: Mwitunde

Yields: lb./acre shelled nuts

<i>Treatment</i>	<i>Yield</i>	<i>Treatment</i>	<i>Yield</i>
Ox cultivation	1,440	Early cultivation	1,570
Hand cultivation	1,580*	Late cultivation	1,530
Tractor cultivation	1,640**		
L.S.D. 5%	115		
Coeff. of Varn.	8.0%		
Mean	1,550		

Sesame

The indigenous variety (*S. angolense*) planted in two drills per 3 foot ridge, and harvested by stooking when the first pods were dry gave 100 lb. seed per acre at Chitedze.

Castor

Inflorescence blight again reduced yields at Chitedze to negligible proportions, and spraying the plants with "Rogor" did not increase yields. The short term, dwarf variety C₁₃ gave 290 lb. per acre seed before the worst of the attack developed.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

GROUNDNUTS

EXPORTS

55 samples of representative export consignments contained an average of 45–46 per cent. oil content, the range being 43–47 per cent., slightly lower than last year, these figures being corrected to 6 per cent. moisture and 3.5 per cent. testa.

The samples were also examined for the proportion of the main types of nuts (Chalimbana, Gambia, Mwitunde, Spanish Bunch and local) to assess broadly the relative amounts of these varieties being grown.

The distribution is shown below.

<i>Chalimbana</i>	<i>Per cent. of each type</i>			<i>Number of samples</i>	<i>Per cent. of samples</i>
	<i>Gambia</i>	<i>Mwitunde and Local</i>	<i>Spanish Bunch</i>		
—	—	100	—	7	13
20	—	80	—	23	42
—	—	80	20	2	3
40	—	60	—	3	5
—	40	60	—	1	2
20	20	60	—	6	11
20	—	60	20	11	21
20	20	40	20	2	3

It is therefore seen that almost 70 per cent. of these samples contained 80 per cent. or more of Mwitunde type seed, and 97 per cent. contained 60 per cent. of Mwitunde type.

The percentage distribution as types in the whole samples were:

<i>Chalimbana</i>	<i>Gambia</i>	<i>Mwitunde and Local</i>	<i>Spanish Bunch</i>
17	4	74	5

Extract from Report of the Entomologist

Hilda patruelis St. (Issidae) was recorded commonly at Chitedze, Tuchila, and generally on groundnuts in highland areas, where it caused severe wilting of the plants in some fields. This insect was last recorded in any numbers in this country on sunn-hemp at Namiwawa in 1922. It is also a pest of cashew. As the attack came late in the season, and as in most fields parasitization of the eggs by a Chalcid was very heavy no control was recommended or attempted. This Issid may be responsible for the larger number than usual of "pops" harvested in some places, and it appears to have been more severe this season than it is normally. It seems to encourage termite attack. It does not appear to have any association with rosette virus, however.

Aphis craccivora Koch. This aphid is a vector of rosette disease and was widespread this season.

Extract from Report of the Plant Pathologist

Rosette of groundnuts was unusually severe in the year under review, and caused almost total loss of crop in certain areas of the Southern Province. The disease was found at its worst in those areas where mean annual temperatures are 70–75°F and mean annual rainfall 30–35 inches. Exceptionally dry conditions after the first planting rains evidently favoured build-up of the vector. The over-wintering hosts of the vector are not known, but it is thought that volunteer groundnuts are not the only hosts. A search in April in one badly affected area failed to reveal volunteer groundnut plants. In another area, equally heavily affected by rosette, infected volunteer plants were discovered in mid-September, having evidently germinated with some heavy rain which fell in July. These were the first volunteers found in the area, giving a period without groundnuts of at least three months. In all areas visited it was pointed out that in the course of early garden preparation, volunteer groundnut plants would be destroyed at least two months before subsequently planted groundnuts would have germinated. From the meagre evidence presented above it would appear that other overwintering hosts might be implicated.

OTHER LEGUMES

Bambarra Groundnuts (*Voandzeia subterranea*)

VARIETY TRIALS

The eight varieties to hand were grown at four stations this year in randomized blocks with four replications. Planted early they gave good yields except at Tuchila, where custom has it that a hoeful of earth should be put on top of each plant after flowering. This was not done but it is not suggested that this is the reason for the low yields.

TABLE 1

Variety: See below

Yield: lb./acre shelled seed

Variety	Colour	Chitedze	Chitala	Tuchila	Mbawa
Northern Rhodesian	Pale Brown	2,340**	1,775	75	2,030***
Barotseland	Cream	2,210*	1,550	90	1,115
Mbawa A.	Cream and Black	1,760	1,440	110	1,815**
Mbawa B.	Purple	2,240*	1,365	80	2,045***
Mbawa C.	Red	1,670	1,350	60	2,360***
Mbawa D.	Pale Brown	1,930	1,750	60	1,715**
Tuchila A.	Pale Brown	1,970	1,540	200	1,170
Tuchila B.	Brown	2,170*	1,605	95	1,470*
L.S.D. 5% .. ..	.. ..	330	None	None	340
Coefficient of Variation .. ..	.. ..	11.0%	20.0%	59.0%	13.4%
Mean .. ..	.. ..	2,040	1,550	95	1,715

The Northern Rhodesian selection is probably the best choice for Central and Northern Provinces, even at low altitude, being of good colour and persistently high yield. All varieties leave about 50 per cent. of their nuts in the ground when lifted.

TIME OF PLANTING OBSERVATION AT CHITEDZE

Besides the four blocks proper of the variety trial planted early, two other blocks were planted at later dates. The necessity for early planting is amply shown by the results.

14th December	2,040 lb./acre seed.
11th January	430 lb./acre seed.
8th February	30 lb./acre seed.

Canadian Wonder Beans (*Phaseolus vulgaris*)

TIME OF PLANTING TRIAL (WITH PHOSPHATE)

To find out the optimum planting date for bush beans, an experiment was laid out at four stations in a randomized block design with five replications, plots being split for presence and absence of phosphate at Chitedze and Mbawa where phosphate is known to be at borderline level in the soil.

TABLE II

Effect of time of planting and phosphate on beans

Variety: *Canadian Wonder*

Yield: lb./acre shelled beans

	Chitedze	Chitala	Tuchila	Mbawa
Soil Type	S.C.L.	—	—	S.L.
pH	6.10	—	—	6.20
Available P. p.p.m.	5	—	—	45
Plant early January	565***	50	680	660***
Plant late January	435	60	280	310
Plant early February	235	40	Nil	350
Plant late February	15	Nil	Nil	20
L.S.D. 5%	110	—	—	130
Nil	260	—	—	330
200 lb. Supers	365***	—	—	375*
L.S.D. 5%	35	—	—	35
Coefficient of Variation	16.4%	failure	—	13.3%

No yields were good this year, and the crop failed completely at Chitala, but it is evident that if any reasonable yield at all is to be expected, the crop should be planted in early January.

Guar (*Cyamopsis psoraloides*)

This newly introduced species was grown at Chitedze and Chitala in the past season. At Chitedze it hardly returned the seed planted, but at the lower altitude of Chitala it gave a very fair yield. Two varieties Texel and Oklahoma were not significantly different from one another and did not respond to 200 lb. superphosphate on Chitala soil. The crop should be planted at 2 rows per ridge, the seed being drilled in the row and later thinned to about a 3 inch spacing in the row. Yields of about 1,000 lb. per acre seed were obtained.

Cowpeas (*Vigna sinensis*)

Cowpea varieties, early planted at Chitedze, were again attacked by *Ascochyta* leaf spot after a very good start to the season. Plants were defoliated and a maximum of 100 lb. per acre seed was obtained.

It appears that one may be able to avoid this disease reaching epidemic proportions by planting the crop in early February, and being content with the healthy but moderate crop produced by this late planting—yields of the order of 400–500 lb. seed may be expected from this system.

Soya (*Glycine max*)

Observation plots, 110 square yards in size, were planted at Bvumbwe to compare five newly imported varieties with Volstate and Pelican which have been grown hitherto. The spacing was 3 feet × 2 rows at 6 inches × 6 inches × 3 plants.

The seed was inoculated. Germination was very good and no insect attacks occurred.

Soya yields (lb. seed per acre) Bvumbwe

				1960		1959	
Volstate ..	..	..	..	2,823	..	1,664	..
Hernon 107	..	..	..	2,420	..	1,966	.. ex Rhodesia
Hernon 147	..	..	..	2,016	..	2,138	.. " "
Pelican ..	..	..	..	1,613	..	1,513	..
51S137 ..	..	..	..	1,613	..	1,437	.. ex Transvaal
54S70 ..	..	..	..	1,210	..	1,734	..
Shelby ..	..	..	..	806	..	—	.. Very early maturing; dwarf.

Shelby is in the wrong latitude for satisfactory yields. The two Hernon varieties appear to be worth further trial.

The medium term varieties of the collection, grown on to renew the seed, yielded 800-1,000 lb. per acre seed at Chitedze.

The long term hay and green manure varieties Hernon 237, Benares and Malaya yielded a maximum of 600 lb. per acre seed. There was a marked response to superphosphate on these plots, yields being doubled by a dressing of 200 lb. per acre superphosphate.

Dolichos (*Dolichos lablab*)

This crop grown at Chitedze produced abundant foliage, but the flowers were attacked and eliminated by the Cantharid beetle (*Mylabris dicincta*) and no seed was set.

Jack Beans (*Canavalia ensiformis*)

The quarter-acre blocks of Jack beans, grown at Chitedze, suffered no pest or disease of note and yielded 2,750 lb. per acre of seed. It is proposed to grow this legume for cattle food next year in place of the soya bean grown to date.

Pigeon peas (*Cajanus cajan*)

VARIETY TRIALS, CHITEDZE

Of the 76 varieties from Gatooma planted at Chitedze in December, 1958, ten have already died out. These are mostly dwarf varieties. 20 more have been uprooted as being unable to persist or bear seed, or for being a poor mixed lot. 11 single plant selections have been made, of which three appear to yield exceptionally well for Chitedze conditions. These conditions are not easy as most of the flowers are usually destroyed by the Cantharid beetle (*Mylabris dicincta*).

DEFOLIATION TRIAL, CHITEDZE

In order to obtain some idea of the reaction of pigeon pea to grazing at different times of year a rough defoliation experiment was conducted on a 3 × 4 factorial design with four replications. The experiment was drilled in 6 foot rows in December, 1958, and defoliated during the dry season of 1959 at three times, either end of July, or mid-September, or end of October. Four degrees of defoliation were applied at each time, involving cutting back the main stem to different heights. The yield of air dried leaf stripped off was weighed and the number of plants surviving in August, 1960, counted.

TABLE III

Effect of defoliating Pigeon Pea

*Variety: Local Unselected**Yields: lb./acre air dried leaf.*

<i>Treatment</i>	<i>No. of plants surviving Aug., 1960</i>	<i>Yield</i>
Defoliated end July	291*	585***
Defoliated mid September	187	445**
Defoliated end October	141	190
L.S.D. 5%	117	140
Cut Plants to Mower height (12 ins.)	87	425
Cut Plants to 36 ins., stump not defoliated	182	410
Cut Plants to 36 ins., stump defoliated	163	410
Plants not cut, but defoliated	187	385
L.S.D. 5%	101	160

A low percentage of plants survived, but early defoliation (July) kills off fewer plants and provides more green stuff than does later defoliation. The leaves tend to fall anyway, and the cutting or breaking of the plant in its dormant state appears to do it no good. The more drastic the damage to the main stem and branches, the greater the loss of stand, though there is very little gain in green stuff. The yield of green stuff from these young plants was miserable, though they were 6-8 feet tall when first cut back. If pigeon pea is to be grazed and yet persist, it should be grazed early, with as little damage to the main stem and branches as is possible, and without completely defoliating the plants. This does not greatly help the supply of nutritious dry season cattle food.

ROOT CROPS

Sweet Potatoes

At Chitedze a $2 \times 2 \times 2$ factorial N.P.K. experiment was laid out to test the response to fertilizer by sweet potatoes grown as the first crop after a ploughed out Rhodes grass ley. The soil contained adequate levels of N and K but low P. There were nevertheless no positive responses to any of the fertilizers either singly or in combination. This confirms previous results on this soil type. These potatoes were planted at the end of December.

TABLE I

Effects of fertilizer on Sweet potatoes

Varieties: Various, each block different

Yield: short tons/acre tubers

Treatment	Yield	Treatment	Yield	Treatment	Yield
Nil	3.75*	Nil	3.42	Nil	3.28
200 lb. S/A ..	3.21	400 lb. Supers	3.54	100 lb. KCl.	3.68
[L.S.D. 5% .. .. .48]		[Coeff. of Varn 18.6%]		Mean	3.48

Irish Potatoes

Of the varieties observed in Dedza last season Kinnebec was markedly affected by late blight, and Pimpinel was discarded as having an unfamiliar red skin not favoured by the consumer. Walanga and Loman 43-35 gave the best yields, with Gineke and Robijn also in the running.

Zineb spray as a control for late blight on the local varieties was rendered ineffective by the weather conditions, a common experience in Rhodeisa.

Extract from Report of the Plant Pathologist

Late Blight, *Phytophthora infestans* (Mont) de Bary overshadows all other diseases. An attempt to protect a crop using a fungicidal spray (Zineb at 2 lb./100 gals./acre) in the main Dedza producing area proved a complete failure. Fungicidal spraying of the rain-grown crop is therefore thought to be a practical impossibility, even if it were economically feasible. It has therefore been decided to use potato varieties showing polygenic field resistance.

Root knot nematode, *Meloidogyne javanica* (Treub) Chitwood was found to be responsible for an irregular blistering of tubers from the Domasi Valley, a minor producing area. So far *M. javanica* has not been found on potatoes from the main Dedza/Ncheu growing areas.

TOBACCO

Dark Fire-Cured Tobacco

Unless otherwise stated all experiments have been carried out at Chitedze Agricultural Research Station. The soils are red-brown sandy clay loam over sandy clay with moderate levels of nitrogen and potassium but very low phosphate content.

This year the quality of tobacco from all experiments at Chitedze was uniformly low, due to a very severe attack of *Alternaria* leaf spot. This fact should therefore be borne in mind when considering any conclusions concerning quality.

1. VARIETY AND FERTILIZER TRIAL

Similar experiments had been carried out in the past two seasons and the object of this trial was chiefly to confirm this previous work. The experimental design was randomized blocks with main plot treatments of 200 lb. sulphate of ammonia and 200 lb. single superphosphate per acre, singly and in combination, together with an overall basic dressing of 80 lb. per acre of muriate of potash. The varieties were planted as split plots, thus increasing the accuracy of the comparison, which was again between local "Western" strains and imported varieties.

TABLE 1A

Dark Tobacco Variety Trial at Chitedze (sub-plots) planted 14th December, 1959

Variety					Yield (lb./acre)
Toleza 58	..	..	..	..	1,056
A.R.S. 53	..	..	..	..	1,036
C.3-42-AA	..	..	..	..	1,034
Greenwood	..	..	..	..	1,030
A.R.S. 51	..	..	..	..	1,030
Type 5	..	..	..	..	1,013
Toleza 59	..	..	..	..	994
Little Crittenden	..	..	..	..	970
A.R.S. 56	..	..	..	..	952
Western: Songea	..	..	..	..	945
C.1-42-A	..	..	..	..	942
Mean	..	..	..	..	1,001
L.S.D. (P=0.05)	..	..	..	..	83
Coef. of Variation	..	..	..	..	10.2%

On the statistical analysis there was no significant difference in yield between varieties, thus confirming that current seed selections yield as well as imported varieties and previous seed selections. Because of the exceptionally low quality of this tobacco, due to disease, no attempt was made to grade out the varieties separately.

Field observations were made on the severity of *Alternaria* damage but all varieties were very badly attacked and there were no visible differences between varieties or fertilizers.

TABLE IB
Dark Tobacco Fertilizer Trial at Chitedze (main plots)

<i>Fertilizer</i>	<i>Yield lb./acre</i>
No fertilizer	805
200 lb./acre sulphate of ammonia	1,084
200 lb./acre single superphosphate	859
200 lb./acre sulphate of ammonia } 200 lb./acre single superphosphate }	1,258
Mean	1,001
L.S.D. (P=0.05)	77
Coefficient of Variation	12.8%

There was a substantial yield increase from the application of sulphate of ammonia and the addition of single superphosphate further increased yield. When applied alone single superphosphate had no effect on yield.

Again, these results confirm those obtained in previous years.

TABLE IC
Dimensions of Green Leaf (middle leaf left after topping and priming)

<i>Fertilizer</i>	<i>Length (ins.)</i>	<i>Width (ins.)</i>	<i>Length/ width ratio</i>
No fertilizer	24.01	9.51	2.584
200 lb./acre sulphate of ammonia	26.97	11.08	2.482
200 lb./acre single superphosphate	25.30	10.86	2.373
200 lb./acre sulphate of ammonia } 200 lb./acre single superphosphate }	29.03	12.57	2.344
Mean	26.33	11.00	2.446
L.S.D. (P=0.05)	1.54	0.82	0.123
Coeff. of Variation	10.11%	12.85%	8.73%

There was very little difference between varieties in green leaf measurements and the differences were of no practical value. The effect of the fertilizer treatments confirms the findings of the past two years. The application of sulphate of ammonia alone significantly increased both leaf length and width over the nil and single superphosphate treatments. The combination of sulphate of ammonia and single superphosphate further significantly increased length and width.

2. CULTURAL TRIALS

Three 3 × 3 factorial topping and priming trials were again carried out at Chitedze (Central Province) and Tuchila (Southern Province). At Chitedze the times of planting were 14th December, 1959, and 6th January, 1960, and at Tuchila 12th December. The treatments for the early planted trials were topping five, six and seven leaves below the crows foot (which is approximately one, two and three leaves below the flag leaf) and priming to leave nine, ten and eleven leaves until harvest. In the late planted trial the treatments were topping seven, eight and nine leaves and priming so that seven, eight and nine leaves remained until harvest. All experiments received a basic fertilizer dressing of 200 lb. "C" mixture (6:18:12) and 200 lb. sulphate of ammonia per acre.

The object of these trials was to determine what combination of topping and priming treatments will give the best combination of yield and quality, judged on grade index and leaf measurements. Unfortunately quality, in which we are primarily interested, was so reduced by *Alternaria* leaf spot that the results cannot be regarded as conclusive.

TABLE IIA
Topping and Priming Trial at Chitedze—Planted 14th December

CURED LEAF

Treatment					Yield (lb./acre)	Grade Index	Crop Index
(a) Topping							
Topping five leaves	..	..	..	..	1,105	26.00	28,720
" six "	..	..	..	..	1,092	24.48	26,739
" seven "	..	..	..	..	1,161	23.58	27,378
(b) Priming							
Harvest nine leaves	..	..	..	..	1,066	27.16	28,958
" ten "	..	..	..	..	1,130	23.66	26,736
" eleven "	..	..	..	..	1,162	23.24	26,999
Mean	..	..	..	..	1,119	24.68	—
L.S.D. (P=0.05)	..	..	..	..	113	2.81	—
Coeff. of Variation	..	..	..	..	10.1%	11.4%	—

TABLE IIB
DIMENSIONS OF GREEN LEAF—TENTH NODE

Treatment					Length (ins.)	Width (ins.)	Length/ width ratio
(a) Topping							
Topping five leaves	..	..	..	..	25.14	10.60	2.38
" six "	..	..	..	..	25.57	11.09	2.31
" seven "	..	..	..	..	26.08	11.43	2.29
(b) Priming							
Harvest nine leaves	..	..	..	..	25.66	10.87	2.37
" ten "	..	..	..	..	25.87	11.20	2.32
" eleven "	..	..	..	..	25.27	11.06	2.29
Mean	..	..	..	..	25.60	11.04	2.33
L.S.D. (P=0.05)	..	..	..	..	0.50	0.31	0.04
Coeff. of Variation	..	..	..	..	1.95%	2.84%	1.92%

None of the treatments in the Chitedze early planted trial had any effect on yield. Topping had no effect on quality but harvesting ten or eleven leaves, instead of nine, significantly reduced quality. The number of leaves harvested did not affect either leaf length or width (F test not significant). Topping seven leaves rather than five or six increased leaf length and lower topping significantly increased leaf width.

TABLE III
Topping and Priming Trial at Tuchila—Planted 12th December

<i>Treatment</i>	<i>Yield</i> (lb./acre)	<i>Quality*</i> <i>assessment</i>	<i>Crop</i> <i>Index</i>
(a) Topping			
Topping five leaves	1,299	63.39	82,363
" six "	1,387	61.88	85,862
" seven "	1,352	62.06	83,896
(b) Priming			
Harvest nine leaves	1,312	64.67	84,857
" ten "	1,331	62.71	83,477
" eleven "	1,395	59.92	83,613
Mean	1,346	62.44	—
L.S.D. (P=0.05)	99	2.79	—
Coeff. of Variation	10.9%	6.6%	—

* This measure of quality is not comparable to grade index because this tobacco was only classified to A.P.M.B. Standards and not fully graded.

The results at Tuchila were similar to those at Chitedze, none of the treatments affecting yield and only the priming treatments having a significant effect on quality. When nine rather than ten or eleven leaves were harvested quality was improved.

TABLE IV
Topping and Priming Trial at Chitedze—Planted 6th January

<i>Treatment</i>	<i>Yield</i> (lb./acre)	<i>Grade</i> <i>Index</i>	<i>Crop</i> <i>Index</i>
(a) Topping			
Topping seven leaves	616	13.49	8,309
" eight "	702	15.03	10,546
" nine "	735	13.41	9,857
(b) Priming			
Harvest seven leaves	638	14.83	9,455
" eight "	706	13.46	9,506
" nine "	709	13.65	9,675
Mean	684	13.98	—
L.S.D. (P=0.05)	75	1.67	—
Coeff. of Variation	11.0%	12.0%	—

Lower topping with the removal of eight or nine instead of seven leaves in this late planted crop gave a significant increase in yield and the increase in yield from harvesting eight or nine, rather than seven leaves almost reached significance. The yield increases from both topping and priming were additive and topping nine and harvesting nine leaves gave the highest yield per acre of all treatments. Neither topping nor priming had any effect on quality.

The plants in the various treatments were measured for leaf length and width but none of the treatments had any significant effect on length, width or length/width ratio.

3. FERTILIZER TRIALS

(a) 25: 10: 0 Mixture Trial at Chitedze

This randomized block experiment was repeated in order to try to gain confirmation of the results obtained last year. The object of the trial was to determine whether nitrogen and phosphate when applied as a compound mixture are as effective as when applied as sulphate of ammonia and single superphosphate.

TABLE V
25:10:0 Fertilizer Trial at Chitedze—Planted 30th December, 1959

<i>Nutrients applied (lb./acre)</i>		<i>Fertilizer</i>	<i>Yield (lb./acre)</i>	<i>Grade Index</i>	<i>Crop Index</i>
N.	P ₂ O ₅				
0	0	Nil	631	16.36	10,325
25	10	100 lb/acre 25:10:0 mixture	760	14.18	10,775
24	0	120 lb./acre sulphate of ammonia	739	15.27	11,289
24	10	{ 120 lb./acre sulphate of ammonia 50 lb./acre single superphosphate }	895	17.61	15,767
50	20	200 lb./acre 25:10:0 mixture	827	15.28	12,554
48	0	240 lb./acre sulphate of ammonia	812	15.00	12,175
48	20	{ 240 lb./acre sulphate of ammonia 100 lb./acre single superphosphate }	1,025	15.28	15,660
Mean			812	15.57	—
L.S.D. (P=0.05)			108	3.26	—
Coeff. of Variation			10.2%	15.8%	—

All fertilizer treatments gave significant yield responses but none had a significant effect on quality. The compound fertilizer gave an equivalent yield to sulphate of ammonia alone but the latter plus superphosphate further significantly increased yield.

These results confirm the findings of the 1958/59 season and this mixture will not be recommended for general use on tobacco.

(b) Nursery—Field Fertilizer Trial

This 3×4 factorial experiment was carried out to see whether fertilizer treatments in the nursery affect the response to fertilizers in the field. The seedbed fertilizer treatments were, Nil, 5 lb. "S" mixture (5:25:5) or 1.25 lb. sulphate of ammonia (21 per cent. N) per 24 square yards. Superimposed upon these in the field were, no fertilizer or 200 lb. sulphate of ammonia and 200 lb. single superphosphate per acre, singly and in combination.

TABLE VI
Nursery-Field Fertilizer Trial at Chitedze—Planted 30th December, 1959

Mean Yield in lb. per acre

<i>Seedbed Treatments</i>				<i>Field Treatments</i>				<i>Mean</i>
				<i>Nil fert.</i>	<i>200 lb. S/A</i>	<i>200 lb. Supers</i>	<i>200 lb. S/A 200 lb. Supers</i>	
Nil fertilizer	..	..	..	519	537	635	763	614
5 lb. "S"	..	..	..	556	789	650	1,004	750
1.25 lb. S/A	..	..	..	550	782	691	1,107	782
Mean	..	..	..	542	702	659	958	715

L.S.D. (P=0.05) for field treatments 75
L.S.D. (P=0.05) for seedbed treatments 65
L.S.D. (P=0.05) for interactions 130
Coeff. of Variation 10.8%

The results of this experiment are summarized in Table VI which has been set out in this form so that the significant interactions between the seedbed and field treatments, can be clearly seen.

From an examination of the seedbed treatments it can be seen that the use of sulphate of ammonia or "S" mixture will increase the yield response to fertilizers in the field; in this instance to sulphate of ammonia alone as well as in combination with single superphosphate. For example, where no fertilizer was used in the nursery the yield from the combined fertilizer dressing in the field was only 763 lb., but was increased to 1,004 and 1,107 lb. where "S" mixture and sulphate of ammonia respectively, were used.

None of the treatments significantly affected quality, which was low.

In conclusion it can be said that in this particular experiment the use of small amounts of fertilizer in the seedbed greatly increased yields in the field, mainly by allowing the plants to make better use of the field fertilizers. However, until these results have been confirmed by further experimentation too much weight should not be attached to them.

(c) Nitrogen, Phosphate and Potassium Trial

The object of this $3 \times 3 \times 3$ factorial experiment was to see how differing levels of nitrogen, phosphate and potash affect the yield and quality of dark fire-cured tobacco. The treatments were nil, 150 and 300 lb. sulphate of ammonia per acre, nil, 250 and 500 lb. single superphosphate per acre and nil, 60 and 120 lb. muriate of potash per acre.

TABLE VII
Nitrogen, Phosphate, Potassium Trial at Chitedze—Planted 30th December, 1959

<i>Treatments</i>	<i>Yield (lb./acre)</i>	<i>Grade Index</i>	<i>Crop Index</i>
(a) Nitrogen			
Nil	657	22.86	15,018
150 lb./acre sulphate of ammonia ..	866	19.01	16,472
300 lb./acre sulphate of ammonia ..	884	18.49	16,349
(b) Phosphate			
Nil	587	22.89	13,441
250 lb./acre single superphosphate ..	865	19.95	17,257
500 lb./acre single superphosphate ..	955	17.51	16,720
(c) Potassium			
Nil	753	20.50	15,437
60 lb./acre muriate of potash ..	815	18.81	15,338
120 lb./acre muriate of potash ..	839	21.04	17,657
Mean	802	20.12	—
L.S.D. ($P=0.05$)	90	3.54	—
Coeff. of Variation	11.1%	17.5%	—

There was a significant yield response to 150 lb. sulphate of ammonia but no further increase from the application of double this amount. Both the single and double rates of superphosphate gave significant yield responses but between the two levels the response is only just significant and would probably not be economic. There was an increase in yield from the higher rate of application of muriate of potash which did not quite reach significance.

The interaction effect of nitrogen and phosphate gave significant yield differences. The results show that the combination of 300 lb. sulphate of ammonia and 500 lb. single superphosphate per acre yielded 1,118 lb. of tobacco per acre, which is significantly higher than any other combination of treatments and also than the mean yield for the experiment. It is inferred from this that when only 150 lb. per acre sulphate of ammonia was applied the response to phosphate was limited by nitrogen shortage and similarly with the application of only 250 lb. superphosphate per acre the response to nitrogen was limited.

The reduction in quality following the use of sulphate of ammonia and single superphosphate, which is contrary to previous experience, may be due to the effect of the fertilizers on the degree of *Alternaria* spotting.

General Conclusions on Fertilizer Trial carried out during the past three years

From the results of all trials carried out by Research Station staff in the past three years there is no doubt that the application of at least 150 lb. per acre of sulphate of ammonia will improve tobacco yields and quality on all soil types in the Central Province and on certain soils there will be a response to heavier applications of nitrogenous fertilizer. On soils with a reasonable phosphate content there will be no yield response to superphosphate but quality will be improved. Where land has been under cultivation for a number of years and soil phosphate is low then yield responses also occur, but only if nitrogen is also applied. At present there is no reason to expect responses to potassium on the majority of soils but it is advisable to apply small amounts of potassium, and phosphate, in order to maintain the fertility status of the soil. This may be done by applying khola manure or artificial fertilizers.

4. OBSERVATION ON THE USE OF ETHYLENE DIBROMIDE AT CHITEDZE

A very small plot of land (1/20 acre approximately) on which eelworm infected tobacco had been grown last year, was divided into three parts. On one plot no fumigant was used whilst on the other two ethylene dibromide was injected at 9 inches and 10 inches. The latter depth should have been 12 inches but on plots ridged by hand it was impossible to get the injector probe to this depth. The tobacco from these plots was sun/air cured and the uprooted plants were scored for eelworm galling.

TABLE VIII
Observational Trial with Ethylene Dibromide

					Not injected	E.DB. at 9 ins.	E.DB. at 10 ins.
Yield (lb./acre)	..	..	..	..	665	991	804
Grade Index	..	..	..	..	12.91	14.57	13.44
Degree of							
root	Nil	..	..	..	14%	38%	45%
galling	Slight	..	..	..	15%	27%	15%
	Moderate	..	..	..	17%	22%	13%
	Severe	..	..	..	54%	13%	27%

There was an appreciable yield increase following the use of ethylene dibromide which appears to be due to a reduction in the number of plants severely galled. The difference between the two levels of application could have been due to differing initial eelworm populations in this unreplicated observation. The quality of this tobacco was again low due to *Alternaria* leaf spot.

Burley Tobacco

All Burley experiments have been carried out at Chitedze on red-brown sandy clay loam soils containing adequate amounts of nitrogen and potassium but having a low phosphate content.

1. VARIETY TRIAL

Five of the varieties tested in the 1958/59 season plus one new variety, Improved Green Briar, were included in this year's trial. The design was 6 replications of a randomized blocks experiment and the object was to confirm that Barnet Special and Stand Upright are still the best varieties available to Nyasaland growers. All plots received a basic fertilizer dressing of 200 lb. "C" mixture (6:18:12) and 200 lb. sulphate of ammonia per acre.

TABLE IX
Burley Variety Trial at Chitedze—Planted 16th December, 1959

Variety				Yield lb./acre	Grade Index	Crop Index	Per cent. coloury	Per cent. Red
Barnet Special	..	..	..	1,873	54.27	101,635	7.2	49.5
Burley 1	..	..	..	1,762	40.42	71,238	3.2	32.1
Burley 21	..	..	..	1,639	39.61	64,937	2.9	33.8
Stand Upright	..	..	..	1,630	52.67	85,859	7.2	48.2
Green Briar	..	..	..	1,603	55.39	88,785	4.6	55.3
Improved Green Briar	..	..	..	1,574	42.71	67,237	2.4	41.0
Mean	..	..	..	1,680	47.51	—	4.6	43.3
L.S.D. (P=0.05)	..	..	..	248	4.82	—	2.5	8.2
Coeff. of Variation	..	..	..	12.4%	8.5%	—	46.1%	15.9%

Barnet Special gave the highest yield per acre and was significantly better than Green Briar and Improved Green Briar. There was no significant difference between the other five varieties. The overall quality of Barnet Special, Stand Upright and Green Briar was significantly better than that of the other varieties. This is reflected in the higher percentages of "coloury" and "red" leaf obtained for these varieties. Any leaf not graded out as "red" or "coloury" is either short X or green and this year there was a high percentage of green spotted leaf due to Frog-eye spot disease (*Cercospora nicotianae* Ell. and Ev.). It was noticeable that those varieties with low quality, particularly Burley 1 and Burley 21, were those which were quickest growing and most attacked by Frog-eye spot.

The "coloury" percentage of all experiments is exceptionally low and this is attributed to unfavourable climatic conditions at curing.

As the coefficient of variation for the "coloury" analysis is so high the results should be regarded with caution. Barnet Special and Stand Upright gave significantly more "coloury" leaf than all other varieties and these two varieties and Green Briar gave significantly more "red" leaf than Burley 1 and Burley 21.

The results of this trial once again show that taking yield and quality together Barnet Special is the best Burley variety available to Nyasaland growers. Stand Upright is not as good as Barnet Special when considered on yield and quality but will give as high a percentage of "coloury" leaf.

2. NURSERY SHADE AND MULCH-FIELD NITROGEN AND PHOSPHATE TRIAL

A previous observation had shown that when grown under identical conditions, mulched plants from the nursery flower earlier than shaded plants. A 3×3 factorial fertilizer experiment was therefore laid out so that the fertilizer plots in the field could be split for shade and mulch plants. The object was to determine whether mulched plants yielded better than shade ones and also if the level of fertilizer applied in the field was important. So that the shaded plants would be the same size as the mulched ones when planted out the seed was sown nine days before that on the mulched beds. Compound "S" mixture (5:25:5) was applied at the rate of 5 lb. per 24 square yards to all seedbeds. The field fertilizers were nil, 150 lb. and 300 lb. sulphate of ammonia and nil, 250 lb. and 500 lb. superphosphate per acre in all combinations.

TABLE X

Shade Mulch and Field NP Trial at Chitedze—Planted 16th December, 1959

<i>Treatment</i>	<i>Yield (lb./acre)</i>	<i>Grade Index</i>	<i>Crop Index</i>	<i>Per cent. coloury</i>	<i>Per cent. Red</i>
(a) Nitrogen					
Nil	1,377	45.83	63,132	12.1	41.2
150 lb./acre sulphate of ammonia	1,642	46.94	77,083	12.5	42.8
300 lb./acre sulphate of ammonia	1,851	47.06	87,096	12.1	43.6
(b) Phosphate					
Nil	1,399	46.97	65,709	10.2	41.0
250 lb./acre single superphosphate	1,666	46.07	76,763	13.1	42.8
500 lb./acre single superphosphate	1,805	46.79	84,468	13.5	43.8
L.S.D. (P=0.05)	255	8.48	—	4.1	8.1
Coeff. of Variation	22.2%	25.7%	—	47.3%	26.9%
(c) Shade —vs— Mulch					
Shaded	1,563	45.96	71,847	12.1	40.7
Mulched	1,684	47.25	79,556	12.4	44.3
Mean	1,623	46.61	—	12.2	42.5
L.S.D. (P=0.05)	80	2.43	—	1.3	2.5
Coeff. of Variation	8.7%	9.3%	—	19.3%	10.3%

The mulched plants yielded 121 lb. more tobacco per acre than the shaded plants and there was no relationship between this effect and the field fertilizers applied. Mulching gave no advantage in quality or percentage "coloury" leaf produced but did increase the amount of "red" leaf, at the expense of low grade leaf.

There were significant yield responses to 150 lb. sulphate of ammonia and 250 lb. single superphosphate per acre but not to the higher rates of application. The responses to nitrogen and phosphate are additive. None of the fertilizer treatments had any effect on quality or percentage "red" or "coloury" leaf produced.

From an analysis of the number of leaves harvested from each plant in every plot it was found that the increases in yield for fertilizer treatments were mainly due to an increase in the number of leaves harvested per plant. There was no difference between the number of leaves at harvest on shaded and mulched plants.

3. TIME AND RATE OF PHOSPHATE APPLICATION

A factorial experiment was conducted at Chitedze to attempt to determine whether the time of phosphate application had any effect on yield or quality of Burley tobacco and if so how this was related to the amount of fertilizer applied.

The fertilizer treatments were 50 lb., 250 lb., and 500 lb. superphosphate per acre with a basic dressing to the whole experiment of 150 lb. sulphate of ammonia and 80 lb. muriate of potash per acre. Time of application was at planting, one week before and one and two weeks after planting.

The average yield for this experiment, which was planted on 24th December, was 1,311 lb. per acre and contrary to expectation there was no yield response to either level or time of application. These results may have been due to late planting but only further testing in the coming year will verify this. The rate of application did not affect quality or "coloury" percentage but did increase the "red" percentage at the expense of low grade leaf. Time of application did not affect either "coloury" or "red" percentages and did not give a clear picture of its effect on grade index. Application one week before planting gave slightly better quality than applying either at planting or one week after. Application two weeks after did not differ significantly from one week before or one week after.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

Flue-Cured Tobacco

FERTILIZER RECOMMENDATIONS

Although leaf shatter, the main problem of a few years ago, seems to have been overcome, and is kept under control by the more extensive use of soil testing for nitrogen requirements, a new problem of the wider occurrence of "slatey" leaf, has now to be considered.

Together with the improved assessments of nitrogen requirements, higher amounts of P and K have also been advised, compared with those used previously. This helps to "buffer" any adverse effect of excess nitrogen due to climatic or other causes. However, the use of higher quantities of potash may be a contributory factor in the greater incidence of slatey leaf, generally considered due to chloride excess. The drier season has also accentuated the trouble. The maximum chloride found in bulk leaf examined was 1.9 per cent. Chloride free mixtures have been advised for "dry" planting this coming season, and the "chloride" experiment being carried out on the Tobacco Demonstration Station, will be followed by soil and leaf analysis during growth.

SOIL NITRIFICATION

A trial was conducted at an estate in the Namadzi area, to follow the seasonal fluctuations in soil nitrate nitrogen and hence to determine the most suitable time for soil sampling for fertilizer recommendations. Two sites were selected and sampled every six weeks. Simultaneously, the first samples taken were stored in the laboratory under varying conditions and analysed for nitrate nitrogen monthly.

The field trial showed the nitrate nitrogen on one field low in July and August (<10 p.p.m.) with a slight increase to a level of 10-20 p.p.m. in October through December. A steady level was maintained to February with slight decrease to a minimum in March and then a sharp increase to 30-40 p.p.m. in April, with slower increase in June, to 40-50 p.p.m.

On each occasion of field sampling the soils were also incubated for two weeks. From one site the two graphs ran parallel, being separated by about 10 p.p.m. On the second, the nitrate released during incubation increased, although the field status

remained fairly steady until March. The total nitrogen status of the two fields was about the same (0.06 per cent.)—but this pattern of nitrate change was consistent with the lower C/N ratio of the second site. The sudden increase in nitrate N after removal of the crop, and the broadly steady level in the growing period suggests that the fertilizer nitrogen assessment for these fields was satisfactory. On the second site, the incubated July samples gave figures corresponding to those obtained in the field in October, but this was not so for the first site. Sampling as close to planting as possible thus covers all instances, and this was particularly important this year when appreciable rain in August/September occurred in areas usually dry at this period.

To deal with the larger number of samples in a short time, extraction procedures have been accelerated, so that the maximum use could be made of the rapid analytical methods already employed. For example, it was found that a quarter hour shaking with ammonium acetate was quite as effective for base extraction as is the conventional overnight soaking. For phosphate, the same shaking time with ammonium fluoride solution was satisfactory for soils containing up to 50 p.p.m. At higher levels, a half hour period gave full extraction for soils containing 100 p.p.m., while longer periods are required for soils of higher P status, but at such a level, the indication that they are high is also given by the quarter hour extraction. It was however found that a reduction of time in the incubation period was not practicable, and so the two weeks for nitrification tests restricts the speed at which recommendations can be made. However 60–70 per cent. of recommendations made on a basis of total N, C/N ratio, and texture agreed with those made on a basis of nitrification tests. The closer field and crop records which are being maintained this year should facilitate the interpretation of these differences and improve advice for future seasons.

N.P.K. TRIAL

Leaf from the previous season's experiment at Chaone was analysed, with similar results as indicated last year, and detailed in the 1957/58 Report. All nutrients, however, appeared generally slightly lower. The nicotine content did not vary considerably with the nitrogen applied, unless the P and K was also at the higher level.

In connection with these determinations, a solvent-extraction method for nicotine was introduced, and comparison of the results with those obtained using silicostic acid shows its suitability and accuracy.

Extract from Report of the Agricultural Chemist, Chitedze

A series of leaf samples were taken from some of the Burley experiments reported in the previous section and analysed for the three major nutrients. The midribs were discarded and only the lamina analysed.

The results confirm last year's findings that there is more nitrogen and less potassium in "red" leaf than there is in "coloury" leaf of the same grade. Differences in phosphate content were negligible. This year the rate of nitrogen applied had no effect on nitrogen content of the leaf.

Leaf samples were taken from different positions on stalk cured plants and it was found that nitrogen content decreased and potassium content increased in the lower leaves. In the light of the above observations on "red" and "coloury" leaf this tends to confirm the generally accepted fact that "coloury" leaf is obtained from the lower part of the plant.

Extract from Report of the Plant Pathologist

TOBACCO—FLUE CURED

Brown leafspot caused by *Alternaria longipes* (Ell. et Ev.) Mason was serious in the Kasungu area, and occurred in other growing areas which have been largely free of this disease in the past. The reason for the severity of the disease this season is thought to have been climatic. The country experienced a three-week drought in January which coincided with topping of the crop. The drought was succeeded by a very wet February. The topped plants became rank in this period, probably due to a nitrogen release on rewetting of the soil, leading to an unbalanced N/PK relationship which is known to increase susceptibility of the plant to *A. longipes*. This supposition was tested by taking soil samples from a badly affected field in the Kasungu area and finding out what quantities of nitrogen would be likely to be released on wetting after air drying for three weeks. The results are presented below:

TABLE XI

No.		Depth	Total organic matter per cent.	Total N per cent.	N released on rewetting p.p.m.	N release lb./acre— 6 ins.
1	.. .. .	0-6 ins.	0.86	.031	27	40
2	.. .. .	0-6 ins.	1.36	.058	20	30
3	.. .. .	0-6 ins.	1.03	.047	24	36

Normal estate practice in the area, based on work done by B. E. J. Wheeler (Misc. Pub. No. 15, C.M.I., 1958. "Investigations on *Alternaria* leafspot of flue-cured tobacco in Nyasaland") has been to apply nitrogen at levels below 28 lb./acre. The amounts of nitrogen released above are in excess of this figure, and represent nitrogen available to the crop at the latter end of the growing season. Considerable unbalance of the N/PK relationship may therefore be expected from a release of nitrogen of the order of that demonstrated above. These preliminary figures show that the soil will release nitrogen on rewetting after three weeks air drying in the laboratory. It is hoped to find out if the same thing happens in the field during the coming year, dependent, of course, on the appearance of a timely three-week drought.

In addition, the wet weather in February provided ideal conditions for the development of the disease, and by slowing harvesting increased the period during which susceptible leaf was in the field.

It is now recommended in Kasungu that topping should be delayed if the plants start flowering during a dry period, i.e. after a week without rain, in order to maintain control of the "greening up" process when rain falls again. If a short drought should occur after topping, it is suggested that a sucker should be allowed to grow up in order to give the same control over greening. Observations in the Kasungu area also indicate that plants affected by root knot nematode, *Meloidogyne* sp., show symptoms of brown leafspot before other plants in the same field.

Tobacco anthracnose, caused by *Colletotrichum tabacum* Böning, occurred on 14 estates during the year. The disease is still restricted to the Southern Province, and does not appear to be gaining ground.

Tobacco mosaic was very prevalent during the year, and in most cases could be ascribed to carelessness in the seedbeds. In addition to normal mosaic symptoms, mosaic spotting and mosaic scorch were common, the latter in some cases being mistaken for brown leafspot by farmers and giving rise to rumours of a widespread

epiphytotic of *Alternaria longipes*. A further symptom, apparently due to a strain of tobacco mosaic virus, was a form of vein necrosis, where the fine veins became necrotic, causing a network of dead tissue.

Leaf curl virus was more prevalent than it has been for sometime past, and a few cases of Bushy top, a comparatively new disease caused by a virus related to rosette, was found in all growing areas. The peculiar growing conditions during the year caused a certain amount of leaf scorch and red rust, both physiological conditions which were confused with *A. longipes* symptoms, again giving rise to alarming reports of an *Alternaria* epidemic.

BURLEY

Alternaria longipes was more serious on Burley than it has been in the past. The reason for this is very probably the same as that for flue-cured tobacco.

Cercospora nicotianae Ell. et Ev. was quite severe on this crop.

Wildfire, caused by *Pseudomonas tabaci* (Wolf and Foster) Stapp again appeared only on Burley tobacco on one estate. This disease first appeared on this estate in 1957 and has appeared every year since. On enquiring into the estate's agronomic practices it was discovered that groundnuts were brought into the rotation in 1957 on one part of the estate, and an increasingly large area of the estate has been put into this rotation in long strips. Wildfire is restricted to that part of the estate where a rotation including groundnuts is practised. A few cases of Bushy top virus were found in Burley crops visited over a wide area.

WESTERN

Alternaria longipes was quite common in the Western crop, though nowhere did it reach the epidemic proportions it did in flue-cured tobacco in the Kasungu area.

Busy top virus was found in a few isolated cases in the Central Province.

A considerable amount of leaf scorching occurred in the hot dry period in January which again gave rise to frightening tales of *Alternaria* epidemics.

TURKISH

Cercospora nicotianae Ell. et Ev. was the commonest leaf disease of Turkish tobacco. *Erysiphe cichoracearum* DC also occurred. Root knot nematode, *Meloidogyne* sp. was very serious in the Northern Province, and may well become a limiting factor on this late planted crop in the very sandy soils in which it is grown.

COTTON

Weather

The 1959 dry season was only slightly drier and warmer, though rather longer, than usual but had no abnormal effect on the cropping or work. November rainfall was normal but was not considered adequate for planting which was delayed until the last week of December except for crops under irrigation which went in several weeks earlier. The rains were light and again finished early by the 3rd week of March leaving a short-fall of 25 per cent. of the normal seasonal total.

A complete summary of all meteorological data at Makanga is given in Table IX. Mention was made last year of a move from the old, sheltered, meteorological site to a new and more exposed site. The move was continued during the year and will shortly be completed with the transfer of the sunshine recorder. Certain records have been made simultaneously at both sites and this will continue for a number of years for comparative purposes.

Cotton Breeding

BY D. F. COLLINGS, E.C.G.C.

(a) INTRODUCTION

Rains were late and trials were planted during the last week in December.

A total of 19.44 inches of rain fell during the growing season December–July, against a sixteen year average of 26.44 inches. January and February were particularly dry, with an increase in sunshine hours of 1.8 hrs./day for each month.

An unusually high boll set on the lower sympodia was observed in all cotton on the station, both irrigated and rain grown. This is not the general rule; in fact shedding of early buds and bolls is one of the main problems in irrigated cotton. The unusual meteorological conditions could account for this deviation from the normal picture, indicating the importance of further investigation into the meteorological aspects of boll shed.

The breeding programme consisted of:

- (1) Selection within Albar 637 and related Albar 51s.
- (2) Selection within crosses between Albar 51 selections and introduced and local varieties.
- (3) New introductions.

There was a complete absence of angular leaf spot on the station, which delayed the culturing of blight bacteria; when cultures were produced the crop was well on in growth, and inoculation gave negative results in all varieties.

The breaking of cross ties in the variety trials resulted in uneven water distribution and growth, and the standard errors were unusually high.

(b) ALBAR 51

The multiplication of Albar 637 has continued, and 1,148 tons of clean seed cotton were produced. Yields were high in areas where rains started early and there was little angular leaf spot. Distribution in the coming season will extend as far south as Nchalo and along the east bank of the Shire as far as Chiromo.

As in the 1958/59 season, the 37 selections from the four best Albar 51 strains, including A.637, have not been outstanding. Eleven have yielded as well as the control (Table II) and will be retained for further testing.

(c) ALBAR CROSSES

None of the Albar 49 crosses ABC.40, ABC.146 or AC.31 has been outstanding, but they will be retained for further testing. UPA (56) yielded less than the control in one trial, but there are indications that it matures two weeks earlier.

Unselected F_3 populations of the 16 crosses made in 1957 between Albar 51 and four local and introduced varieties were tested against A.637. The results of this trial were intended as a guide to which crosses were most likely to produce high yielding selections. Similar trials at Makanga and Chitala gave contradictory results, but this may be attributed partly to the high standard error at Makanga (Table I). The trial will be repeated in 1960/61.

Single plant selections made in the F_2 were grown in unreplicated progeny rows. No selection was possible for resistance to bacterial blight (*see (a)* above). Jassid infestation was high; with discards for this factor and for low lint index, the amount of material has been reduced to more manageable proportions and will be tested for blight resistance and yield in the coming season.

Further selections were made for small plants and for high boll set in the bottom two feet. These will be compared under irrigation with A.637 and CLB which grow excessively tall under these conditions; this will also minimize the uneven water distribution experienced under rain-grown conditions.

(d) INTRODUCED VARIETIES

Four families of BAR 11/9 homozygous for B_2 B_3 B_6 and BARHOP 7 were included in the Albar crosses trial (Table I). All are very susceptible to jassid attack and yields are inconsistent as a result.

TABLE I
Albar Crosses Trial
Yields in lb. seed cotton/acre
Station Trials

Variety				Makanga	Chitala
CLB	} (controls)	..	..	895	392
A637				1,123	621
509	..	..	..	1,014	688
513	..	..	..	856	705
514	..	..	..	899	862
516	..	..	..	1,012	773
518	..	..	..	917	846
519	..	..	..	1,111	752
521	..	..	..	981	688
524	..	..	..	1,210	780
F2	..	..	..	398	403
F18	..	..	..	611	529
F21	..	..	..	692	326
F22	..	..	..	672	12.0
S.E.	..	..	..	± 220	± 30
LSD 5%	..	..	..	235	39
(for comparison between Controls and other varieties)					
C. of V.	..	..	..	24.5%	5.02%
Reps.	..	..	..	6	6
Planted	..	..	..	29-12-59	10-12-59

Plot size 1/145 acre. Spacing 3 ft. × 2 ft. 3 plants/hole.

TABLE II

Cotton Variety Trial

Yields in lb. seed cotton/acre

Variety				Makanga	Ngabu
CLB	} (controls)	..	..	1,024	1,428
A637				1,014	1,723
7/104	..	..	..	904	1,774
122	..	..	..	947	1,700
132	..	..	..	1,150	1,658
158	..	..	..	1,111	1,667
230	..	..	..	979	1,922
246	..	..	..	1,153	1,755
262	..	..	..	1,001	1,686
271	..	..	..	1,137	1,681
273	..	..	..	1,090	1,640
282	..	..	..	1,207	1,691
323	..	..	..	1,076	1,714
AC31	..	..	..	939	1,695
ABC146	..	..	..	954	1,139
ABC 40	..	..	..	1,176	1,399
UPA(56)	..	..	..	822	1,459
A(56) (22)	..	..	..	913	1,301
A367G	..	..	..	920	1,649
S.E.	..	..	..	± 249	± 146
LSD 5%	..	..	..	260	211
(for comparison between Controls and other varieties)					
C. of V.	..	..	..	25.6%	9.4%
Reps.	..	..	..	6	3
Planted	..	..	..	29-12-59	2-1-60

Agronomy

(written in collaboration with D. F. COLLINGS, E.C.G.C.)

(a) COTTON

(i) *Shedding*. Following preliminary observations last year, a formal trial was put down in which two insecticides, Sevin and Endrin, and two fruit drop hormones, Planofix and 2:4:5: TP, should be sprayed weekly from 1st January to 15th February in a 3×3 factorial layout with three replications, planted with CLB, A.637 and UPA respectively. The 2:4:5: TP caused growth distortion of the plants, and this treatment was stopped after two applications. Sheds were collected regularly during the period of the spraying, and harvesting was completed in ten pickings.

The trial was planted on 15th November with supplementary irrigation, so that flowering would take place in January and February. The increased yield from the hormone treatment last year was entirely due to a reduction in the shedding of fruit from flowers opening during these two months.

The results given in Table III and Fig. 1 appear at first sight to contradict last year's observations, when Planofix gave an increase in yield, and insecticide appeared to have no effect. Conditions this year were, however, very different and probably atypical; the shedding in January and February was much less severe than usual, apparently connected with the dry sunny weather, and there was little or no difference between the Planofix treatment and the control. The increased yield from the insecticide treatments requires confirmation over a number of seasons, as any infestation is likely to be affected by climatic conditions. Much of the increase in fact came from the UPA, and may have been the result of jassid control in a relatively susceptible variety. UPA also yielded a much bigger crop in the first three pickings than the other varieties.

Significant reductions in the number of sheds collected were recorded at various dates in the Sevin and Endrin treatments, and in the plots receiving 2:4:5: TP; this treatment was also found to delay the abscission of the corolla very markedly. A relationship between reduction in shedding and earliness of harvest as expressed in the yields of the first 3 picks was sought by analysis of covariance and by calculation of the expected gain in yield on the basis of 1 pound of seed cotton for every 100 bolls retained. The differences in yield of the first 3 picks were not satisfactorily explained by recorded differences in shedding; the increased yield with Sevin was far greater than the reduction of shedding would lead one to expect while 2:4:5: TP reduced shedding but also had a lower yield in the first 3 picks due to the damage it caused to the plants.

TABLE III
Cotton Shedding Experiment, Makanga

Treatment				Yield—pounds seed cotton/acre		Sheds collected per acre		Grain expected from reduction in shedding in pounds/acre		
				Total	To 31 March	Up to 29 Jan.	Up to 16 Feb.	Up to 29 Jan.	Up to 16 Feb.	Actual
Control	..	..	..	2,291	965	10,820	103,719	—	—	—
Planofix	..	..	..	2,490	1,040	8,882	99,630	20	41	75
2:4:5: TP	..	..	..	2,070	515	6,250	73,821	45	299	450
Control	..	..	..	2,019	455	11,222	99,734	—	—	—
Endrin	..	..	..	2,336	630	7,772	82,505	34	172	175
Sevin	..	..	..	2,496	1,436	6,957	94,930	42	48	981
S.E.	..	..	..	±167	±75	±823	—	—	—	—
LSD 5%	..	..	..	500	228	2,468	—	—	—	—
1%	..	..	..	689	314	3,391	—	—	—	—
0.1%	..	..	..	949	433	4,658	—	—	—	—
C. of V.	..	..	..	21.9%	27.2%	28.2%	—	—	—	—
A637	..	..	..	2,549	721	9,366	89,746	15	91	—31
CLB	..	..	..	2,269	752	10,863	98,851	—	—	—
UPA	..	..	..	2,034	1,044	5,722	88,572	51	102	292

(ii) *Cotton-Maize Interplanting.* It was planned to repeat the experiment reported last year when interplanting gave significantly higher yields of maize and cotton from the same area of land than pure stands. The late advent of the rains telescoped the early and late planting dates cotton into one and only a simple comparison of pure stand and interplanting was possible. The results in Table IV show no differences in yield between the methods, the effect possibly of a drier year which also greatly reduced maize yields.

Fig.1 Effect on shedding and harvesting patterns of cotton of various hormones, insecticides and varieties

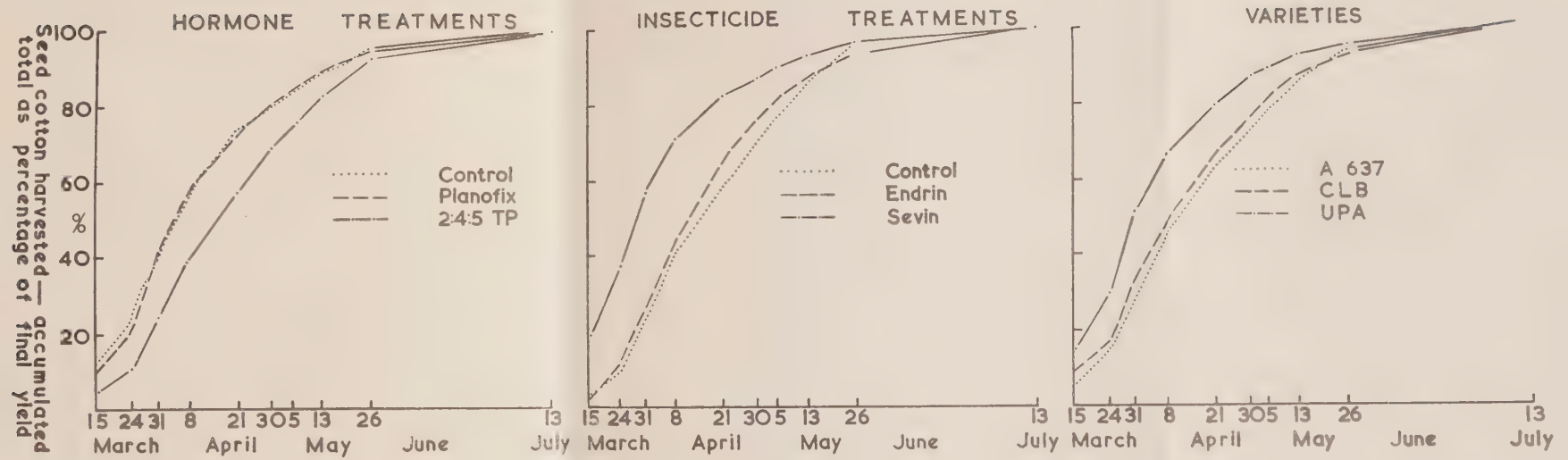


TABLE IV
Interplanting of Cotton and Maize, Makanga

System	Yields in lb. from 2 acres	
	Seed Cotton	Shelled Maize
1 acre pure stand of each ..	1,362	+887
2 acres interplanted ..	1,341	+928
LSD 5%	213	486
Coef. of Var.	22.9%	53.6%

(b) CULTIVATION TRIALS

Ridging and Mulching Trial. This is the seventh year of this experiment. As in previous years both mulching and boxing markedly increased yields. The increase from mulching was from 4 bags to 10 bags per acre, significant at .1 per cent. but boxing only significantly (5 per cent.) increased yields in the absence of mulching. Table V gives a summary of the results to date.

TABLE V
Ridging and Mulching Trial
(Yields in pounds per acre.)

Year	53/54	54/55	55/56	56/57	57/58	58/59	59/60
Crop	Maize	Maize	Cotton	Maize	Cotton	G/Nuts	Maize
Rainfall Nov./Apr. in.	20.97	37.96	23.43	28.29	20.63	27.48	20.77
Date of Planting ..	10 Dec.	30 Nov.		29 Nov.	3 Dec.	11 Jan.	29 Dec.
Flat	383	1,483	floods	2,121	804	423	1,337
Ridged	551*	1,448	destroyed	2,304	783	466	1,553
Boxed	734*	1,515	crop.	2,436*	814	589*	1,767*
No mulch	344	1,489	Stalk	1,825	705	358	768
Light mulch	602*	1,534	weight	2,102*	876*	529*	1,857*
Heavy mulch	722*	1,426	indicated	2,935*	821*	610*	2,034*
			response				
LSD 5%	127		to mulch.	234	96	126	513
C. of V.	33%			15%	17.8%	22%	49.1%
Interaction	—	—	—	not sig.	significant negative interaction box × mulch		

TABLE VI
Rotation Trial

Yields in lb./acre seed cotton, shelled maize and shelled groundnuts

<i>Phase</i>	<i>Treatments</i>	1957/58	1958/59	1959/60
A		(cotton)	(groundnuts)	(maize)
	1. continuous cropping 3 course rotation	450	991	897
	2. as above with f.y.m. one year in three	411	854	1,510
	3. 3 years crops 3 years bush fallow	428	759	1,010
	4. 3 years crops 3 years bush fallow	fallow	fallow	fallow
	LSD 5%	103	81	465
	Coef. of Var.	15%	19%	23.6%
B		(groundnuts)	(maize)	(cotton)
	1. continuous cropping 3 course rotation	888	2,646	802
	2. as above with f.y.m. one year in three	932	2,125	715
	3. 3 years crops 3 years bush fallow	892	2,390	fallow
	4. 3 years crops 3 years bush fallow	fallow	fallow	846
	LSD 5%	103	367	197
	Coef. of Var.	7%	18%	14.4%
C		(maize)	(cotton)	(groundnuts)
	1. continuous cropping 3 course rotation	3,481	680	428
	2. as above with f.y.m. one year in three	3,532	855	409
	3. 3 years crops 3 years bush fallow	3,430	fallow	fallow
	4. 3 years crops 3 years bush fallow	fallow	872	506
	LSD 5%	242	163	213
	Coef. of Var.	4%	23%	27.6%

(c) ROTATION TRIALS

(i) *Rotation Trial 8/10.* The results for the first three years of this trial are given in Table VI. It is early yet to draw any conclusions.

(ii) *Continuous Cultivation Trial 8/11.* Three years results are likewise given for this trial in Table VII. Treatments 3 to 7 were incorrectly cropped in 1959/60. Again no conclusions are drawn.

TABLE VII

Continuous Cropping Trial 1958/60 (8/11)

Yields in lb./acre of seed cotton, shelled maize and shelled groundnuts

<i>Treatment</i>					1958	1959	1960
1.	Continuous cotton	..	..	crop yield	cotton 562	cotton 1,227	cotton 882
2.	Continuous maize	..	..	crop yield	maize 3,894	maize 2,985	maize 474
3.	Maize/cotton (Phase I)	..	..	crop yield	cotton 538	maize 2,994	maize 607
4.	Maize/cotton (Phase II)	..	..	crop yield	maize 3,920	cotton 1,313	cotton 778
5.	Maize/cotton/legume (Phase I)	..	..	crop yield	cotton 593	legume 533	legume 307
6.	Maize/cotton/legume (Phase II)	..	..	crop yield	legume 896	maize 3,258	maize 717
7.	Maize/cotton/legume (Phase III)	..	..	crop yield	maize 3,690	cotton 1,273	cotton 718
Maize LSD 5%					424	320	81
C. of V.					6.8%	12.0%	7.8%
Variety					Makanga	Mlonda	Mlonda
Cotton LSD 5%					146	156	260
C. of V.					15.9%	14.2%	19.0%
Variety					A637	A637	A637

(iii) *Exhaustion Plots.* Monocropped one acre exhaustion plots were maintained for maize and cotton. Yields to date are given in Table VIII.

TABLE VIII

Yield of Exhaustion Plots

	<i>Maize</i> <i>lb. grain</i> <i>per acre</i>	<i>Cotton</i> <i>lb. seed cotton</i> <i>per acre</i>
1954	896	—
1955	1,755	—
1956	Floods	Floods
1957	1,780 { Makanga Selections 100 lb. S/A/acre	1,000
1958	2,106 Makanga Selections ..	500
1959	1,780 Mlonda	1,470 A637
1960	707 Mlonda	614 A637

TABLE IX
Meteorological Data—Makanga 1959/60

Month	Rainfall		Humidity		Temperature		Sunshine		Open Pan Evaporimeter		Piche Mean ccs daily		Wind New Site Mean Miles per day
	New Site	Rainy days	Old Site		Minimum		Old Site		New Site		Old Site		
			59/60	Mean	59/60	Mean	59/60	Mean	59/60	Mean	New Site	Old Site		Mean
	59/60		Mean		59/60	Mean	59/60	Mean	59/60	Mean	59/60	Mean	
May ..	—	0	0.00	(16)	91.9	(16)	60.8	60.6	6.36	5.18	202.6	(2)	182.6
June ..	—	3	0.24	0.74	84.3	80.7	56.7	54.7	3.94	3.94	154.3	132.3	132.3
July ..	—	5	0.69	0.40	83.7	82.1	57.0	54.4	4.77	4.58	168.5	165.2	165.2
August ..	—	5	0.76	0.37	87.0	85.6	56.6	56.7	5.92	5.66	223.9	215.0	215.0
Sept. ..	—	1	0.16	0.25	89.7	91.7	63.1	62.3	7.76	7.71	295.3	299.9	299.9
Oct. ..	—	3	0.63	0.57	97.0	97.3	68.7	70.0	**	10.89	444.9	415.8	128.4 143.6
* year Mean/Total			2.48	3.09		87.1	59.9	8.3	39.64	37.39			
			1:1 confidence (17) limits			(17)	72.4	(5)				(3)	
Nov. ..	3.34	7	3.47	1.77 4.72	94.3 *	96.3	70.4 *	8.4	8.5	10.66	294.5	392.6	122.1 126.6
Dec. ..	3.34	10	3.61	4.20 7.79	95.7	92.6	74.3	6.8	7.0	9.76	339.8	246.9	102.0 116.4
Jan. ..	5.04	8	5.21	3.68 9.17	95.9	91.5	70.1	8.4	6.9	8.44	258.2	226.3	79.7 89.7
Feb. ..	3.63	12	3.69	3.28 8.85	92.5	90.6	71.8	7.4	7.0	7.19	198.9	163.8	118.2 69.3
Mar. ..	4.17	9	4.29	2.49 5.15	89.0	88.4	69.6	7.4	8.2	6.01	166.6	141.3	66.5 77.2
Apr. ..	0.48	6	0.50	0.37 2.06	87.0	88.5	66.0	7.8	8.5	5.68	155.0	171.9	60.5 76.1
* year mean/Total	20.00		20.77	27.95		91.3	70.4	7.9	7.7	47.74	43.15	39.46	
	—		23.25	31.04				82.79	76.85				

N.B. Bracketed figures in "mean" columns refer to the number of years over which the means below it are taken.

No means are yet available for the new site.

* The Stevenson screen was moved to the new site on 1st December, 1959, and records thereafter refer to the new site but the corresponding means are for the old site.

** Pans painted black inside.

Extract from Report of the Entomologist

Work on cotton was confined mainly to investigations on *Dysdercus* spp. These investigations are summarized briefly in the report on Cotton Pest Research (C.D.W. Scheme R817), p. 68.

Throughout the country the incidence of most pests was low, largely due to the dry season. The initial infestation of *Diparopsis castanea* (Red Bollworm) was estimated as lower than in the 1956/57 season, but at a similar level to that of last season. Populations of *Dysdercus* were very low in the critical months of November to April, as they have been since 1955.

Heliothis armigera (American Bollworm) occurred in numbers only in a very few local areas in Central Province. At Toleza Farm, where some Albar 637 is being bulked, a higher incidence of this bollworm occurred than was found in nearby cotton areas, and in March D.D.T. was used successfully as a control.

Sylepta derogata (Cotton Leaf-roller) was commoner than usual on the Lake-shore, although only local outbreaks, affecting a few gardens severely, were recorded. Only a single infestation of *Calidea dregii* v. *apicalis* was found in the Lower River: elsewhere adults of this insect were seen only rarely in the crop in April and May, not at all at other times.

Anoplocnemis curvipes (Bow-legged Bug), although numerous in the highland areas this season in March and April, limited its attacks to other crops and was recorded rarely on cotton. *Oxycarenus hyalinipennis* (Seed-bug) was, as usual, very common on the maturing crop. *Empoasca facialis* (Jassid) appeared to be rather more numerous on the early crop this season than last, but only minor damage occurred owing to the high degree of resistance of the cotton varieties grown here, and young plants, noticed as quite severely damaged, grew away from the attack.

Zonocerus elegans (Elegant Grasshopper) was widespread and more numerous than usual on cotton in the Lower River as was *Hodotermes mossambicus* (Harvester-termite). Both these pests appear to do more damage to cotton in December to February in the Lower River when conditions are drier than normal, possibly because new succulent weed-growth is more limited than in years of higher early rainfall. In the past in this country little success has been achieved in Elegant Grasshopper control although various baiting techniques have been used as well as many modern contact insecticides. Recently a new carbamate insecticide, Sevin, was tested against this pest. A 0.1 per cent. solution of Sevin 50 per cent. W.P. gave an excellent control in two areas where a serious attack was in progress, and it is proposed to follow up this initial success, and test other concentrations of the insecticide against Elegant Grasshopper, and to investigate the effectiveness of the dust formulation.

Red Spider (?*Tetranychus* sp.) occurred in great numbers on a plot of irrigated out-of-season cotton at Makanga. The attack was successfully controlled with Rogor 40 in October.

A severe attack of Blackarm (*Xanthomonas malvacearum*) occurred on some plots of CLB cotton in Fort Johnston area, and on a few gardens in the Lower River on the same cotton variety, but the disease level was otherwise normal.

Extract from Report of the Plant Pathologist

Bacterial blight, caused by *Xanthomonas malvacearum* (E.F.S.) Dowson was particularly severe in the Makanjila area of Fort Johnston District. It is hoped to distribute seed of Albar 637, a resistant variety, in this area next year and its performance will be watched with interest.

COTTON PEST RESEARCH SCHEME (C.D.W. SCHEME R817)

Annual Report for the 1959/60 Season (Abridged)

Introduction

The division of work of the Cotton Pest Research Team follows a similar pattern to that of previous seasons in that the basic investigations into the biology and control of cotton bollworms, together with toxicological studies, continue to be carried out at the Gatooma Research Station, Southern Rhodesia, while investigations into the biology and control of cotton stainers continue at the Makanga Experiment Station, Nyasaland. Insecticide trials together with associated biological studies based on the work at Gatooma and Makanga have been carried out at the Chitala Experiment Station, Nyasaland, and Sabi Valley Experiment Station, Southern Rhodesia and in Northern Rhodesia.

The work on cotton stainers at Makanga has had to be reduced in scope owing to the appointment of Mr. R. C. H. Sweeney to the post of Government Entomologist, Nyasaland, and the failure to recruit another entomologist in his place. However, Mr. Sweeney has been able to supervise the continuation of the more important cotton stainer investigations.

The Cotton Pest Research team has been augmented by the appointment of two Technical Assistants, one of whom is stationed at Gatooma, while the other is stationed at Makanga. These appointments have helped, considerably, to broaden the scope of the cotton pest investigations.

General

A Research Fellowship to study diapause in *Diparopsis* tenable at the University College of Rhodesia and Nyasaland has been approved, and it is hoped that this work will be started within the near future.

At the First Federal Science Congress held in Salisbury in May, 1960, papers were presented by the three members of the team. These papers have been accepted for publication in the Proceedings of the Congress, the titles being as follows:

"The Biology of Cotton Bollworms in the Federation of Rhodesia and Nyasaland," by J. P. Tunstall.

"The Evaluation of Insecticides for Cotton Insect Pest Control," by G. A. Matthews.

"The Biology and Control of Cotton Stainer-bugs (*Dysdercus* spp.) in the Federation," by R. C. H. Sweeney.

The following paper has been accepted for publication by the Empire Cotton Growing Corporation in their Review:

"A Modified Knapsack Sprayer for the Application of Insecticides to Cotton," by J. P. Tunstall, G. A. Matthews and A. A. K. Rhodes.

Investigations at the Gatooma Research Station

GENERAL

The 1959/60 season was characterized by a severe drought over the period of sowing, and at subsequent intervals during the season. The total rainfall was just under 20 inches for the season. The growth of cotton was very poor, generally, and all field insecticide trials were adversely affected, the amount of information which it was hoped to obtain from these trials being greatly reduced. However, progress was made in the purely biological investigations and, also, in the toxicological studies and methods of spray application.

The biological investigations have mainly concerned *Diparopsis castanea* Hmps., as in previous seasons, although during the 1959/60 season it was possible to carry out preliminary behaviour studies on *Heliothis armigera* Hbn.

(a) *The behaviour and natural mortality of Diparopsis under field conditions*

Natural loss of *Diparopsis* eggs from the plant was recorded at intervals during the season. In contrast to the previous season, when 34 per cent. of the eggs were lost through ant attack in April/May, only 1.0 per cent were recorded as being lost due to this cause throughout the season. A further 19 per cent. of the eggs were lost through rain, while 25 per cent. were lost through no obvious cause. Thus the loss of eggs from all causes averaged 45 per cent., and at no time did it exceed 70 per cent., whereas during the previous season losses of up to 100 per cent. were recorded. The differences in losses of eggs between the two seasons is attributed to the lack of predacious ants and to the low rainfall of the 1959/60 season. The incubation period varied from 6–9 days.

Observations were made on the behaviour and natural mortality of *Diparopsis* from egg hatch to emergence from the soil as an adult moth. Three batches of eggs, hatching in February, March and April, were used, thus allowing observations to be made throughout the season.

The time of egg hatch and the period and nature of larval wandering before penetration of a fruiting point were similar to that shown by the previous season's observations. Larval mortality over this period of the life cycle for eggs hatching in February, March and April was 21 per cent., 21 per cent. and 26 per cent. respectively, most of which was accounted for by larvae ceasing movement and dying without any apparent cause. A small number of larvae were killed by Syrphid larvae and spiders.

The mean length of the larval stage for the three periods of the season was 2', 20 and 21 days respectively. This was a considerably shorter period than for the previous season, when the mean larval period in March/April was recorded as 38 days. It is thought that differences in available food and climatic conditions between the two seasons affected the length of larval period.

The mean length of the pupal stage was 23 days and 19 days for eggs hatching in February and March respectively. With eggs hatching in April, there were insufficient moth emergences to record pupal period. Thus, with a mean incubation period of eight days, the mean length of life cycle from egg to adult moth was approximately seven weeks.

The exposure of larvae during transfer from one fruiting point to another during pupation and at other times when the larva re-enters the same fruiting point was measured. All major movements, namely transfers and pupations, took place during the hours of darkness, principally between 18.00 and 24.00 hours. Other movements, also, tended to be concentrated over this period. Transfer movements most commonly occurred from the 12th to the 19th 24-hour period following egg hatch, although there were variations during the season. During February, the larvae tended to make two or three transfers during the larval stage, but later in the season, the majority of larvae made only one transfer. As in the previous season, it was seen that many infested buds, developed into bolls, the feeding of the young larvae keeping pace with bud and boll development for a limited period.

Moth emergence, also, was confined to the hours of darkness, all emergences taking place between 21.00 and 02.00 hours.

Larval mortality from the initial bud or boll penetration to entry into the soil on pupation for the three periods over which observations were made was 0.0 per cent., 19 per cent. and 8 per cent. respectively. This was lower than for the previous season (March/April), when larval mortality over this stage of the life cycle averaged 44 per cent. It was not possible to measure pupal mortality with any degree of accuracy, owing to the presence of other pupae in the ground.

As with the loss of eggs, lower mortality in the larval stage in 1959/60 as compared with 1958/59 was largely due to the lack of predacious ants. The only predators recorded were *Agonoscelis versicolor* Fabr. and other predacious bugs (unidentified). Death of *Diparopsis* larvae also resulted from *Heliothis* larvae invading infested buds and bolls.

(b) *The proportion of Diparopsis larvae forming overwintering pupae and the period of subsequent moth emergence under pupation garden conditions*

The proportion of larvae forming overwintering pupae increased as the season advanced, and had reached 96 per cent. by the end of April (1958), as compared with 100 per cent. in other seasons.

Emergence of moths from overwintering pupae during the 1959/60 season extended from December to March, with a distinct peak of emergence during January. Generally, the period of main emergence was later than for the 1958/59 season. There was, also, a small peak of emergence towards the end of February. A small proportion of the pupae had not given rise to moths by the end of the season.

(c) *The emergence of Diparopsis moths from overwintering pupae under field conditions*

For the third season in succession, field emergence cages were laid down on the previous season's cotton land, to record the emergence of *Diparopsis* moths from pupae produced naturally in the field. Field cages were set down on both fallow land and on land which was cultivated and subsequently sown to maize. The purpose of the latter was to determine whether the shading effects of maize, etc., would modify the pattern of moth emergence.

On fallow land, the period of moth emergence extended from September to the end of March with two peaks of emergence, one during January/February and one during February/March. Compared with the previous two seasons, the main period of emergence was distinctly later, and with more distinct peaks of emergence. A small proportion of pupae were still alive in the soil at the end of the season.

The pattern of moth emergence was similar on cultivated land. However, owing to the poor rains, the growth of maize was poor, and there was less shading effect than would be the case normally.

The field emergence cages gave a somewhat different emergence pattern than the cages in the pupation gardens. With the former technique the emergence period was extended, and the peaks of emergence were less steep.

(d) *The effect of temperature in Diparopsis moth emergence from overwintering pupae*

Overwintering pupae collected in July and August, 1959, were subjected to continuous temperatures of 75°F and 55°F. Whereas moths emerged from the 4th week following date of pupal incubation at a temperature of 75°F, at 55°F pupal development was completely suppressed. Pupal development continued to be suppressed if pupae at 55°F were transferred to 65°F, but with pupae transferred from 55°F to 75°F, development recommenced normally.

(e) *The effect of depth of pupation on Diparopsis moth emergence from overwintering pupae*

Overwintering pupae collected from the field towards the end of the 1958/59 season, were set in pupation garden cages at depths of $\frac{1}{2}$ inch, 1 inch, 2 inches, 3 inches, 4 inches, 6 inches and 8 inches. The subsequent emergence pattern of moths was similar to that obtained in the previous season, the moths from pupae set at the deeper depths emerging earlier than from pupae set at the shallower depths.

An extension of the pupation garden experiment was carried out on a small field scale. Pupae collected from the field were evenly distributed at depths of 0-4 inches and 4-8 inches. Subsequent moth emergence showed that the pattern of emergence for the two depth intervals was very different. By the end of December 84 per cent. of the total moth emergence had taken place from pupae set between 4 inches and 8 inches compared with 36 per cent. at the 0-4 inches depth interval.

It is considered that mechanical inversion of the soil, which would bury pupae to the required depth, offers a possible means of control, through reducing the effective portion of the carry-over moth flight of *Diparopsis*. It might also allow a reduction in the weekly spraying schedule at present being recommended. This control measure, however, would only be possible on land having sufficient depth of top soil.

(f) *The effect of mulching on the emergence of Diparopsis moths from overwintering pupae*

It has been shown that a thick grass mulch, 6-8 inches in depth, suppressed overwintering pupal development throughout the season. Further work on the effect of mulching is to be carried out, but, at present, it would seem likely that the suppression resulted from both a temperature and moisture effect.

(g) *The behaviour and natural mortality of Heliothis under field conditions*

During March, 1960, similar observations to those made on the behaviour of *Diparopsis* were made on *Heliothis*. The observations were preliminary in nature, and further work is to be carried out. It was noted that, in contrast to *Diparopsis*, egg hatching occurred mainly between 07.00 and 13.00 hours, and that transfer movements were very much more frequent. Eight and 12 transfers were recorded on two larvae which completed their larval cycle. Furthermore, major movements, such as transfers, occurred mainly during the day and not at night as in the case of *Diparopsis*. Predacious bugs, ants and spiders were predators which were observed. Cannibalism also occurred in the field.

(h) *The rearing of Diparopsis, Heliothis and Dysdercus*

Cultures of *Diparopsis* and *Heliothis* have been maintained successfully throughout the year, food for *Diparopsis* during the winter months being obtained from cotton plants grown in the greenhouse. Since the latter part of the season, successful cultures of *Dysdercus* spp. have also been maintained.

The mass rearing of these insects, coupled with the possibility of storing *Diparopsis* pupae at 65°F, provides a continuous supply of insect test material throughout the year.

THE CHEMICAL CONTROL OF DIPAROPSIS AND OTHER INSECT PESTS OF COTTON

Further laboratory bioassays have been carried out in conjunction with field trials, and have shown that the insecticide Sevin is very effective against *Diparopsis*.

(a) *Toxicity Tests*

The behaviour and mortality of *Diparopsis* 1st instar larvae from the time of egg hatching was assessed by continuous observation of potted plants in the laboratory. The plants were sprayed to "run-off" and eggs placed on the upper surface of the leaf, the stem, or on the bract of a bud. Eggs hatched between 04.00 and 09.00 hours

and the larvae were observed continually until they had died or penetrated a bud. The observations showed that the wandering period before death on plants sprayed with Sevin was less than for either D.D.T. or endrin at comparable concentrations. Comparison with data for unsprayed plants indicated that the extent of wandering on sprayed surfaces was restricted.

The mortality of adult *Diparopsis* moths caged over plants sprayed with Sevin, D.D.T. and endrin, indicated that endrin was more toxic than Sevin. Endrin at a concentration of 0.025 per cent. gave 100 per cent. kill, as against 75 per cent. with 1 per cent. Sevin. D.D.T. appeared to have little or no effect on the moths, when sprayed at a concentration of 0.1 per cent.

Toxicity tests with *Heliothis* have shown that D.D.T. is more toxic than Sevin. In a small field trial, the natural *Heliothis* larval population was reduced by 93 per cent. on plots sprayed with 1 lb. D.D.T. in 10 gallons of water per acre, compared with 56-75 per cent. reduction on plots receiving Sevin at $\frac{1}{2}$ lb., 1 lb. and 2 lb. in ten gallons of water per acre.

Preliminary results of toxicity tests with *Dysdercus* by caging adults over bolls dipped into insecticide of various concentrations indicated that *D. intermedius* is less susceptible to Sevin than *D. fasciatus*, and that Sevin is more toxic to *D. intermedius* than D.D.T.

Further results of toxicity tests are given in the paper presented by Mr. Matthews at the Federal Science Congress.

(b) *Spray Coverage Assessments*

A limiting factor in the use of low volume insecticide sprays (10-20 gallons/acre) for the control of cotton insect pests, particularly *Diparopsis*, is the difficulty of achieving an adequate spray coverage of the plant. The biological studies on *Diparopsis* egg placement and larval behaviour have shown that a uniform coverage of insecticide over the plant is required for maximum control. During the 1959/60 season, spray coverage assessments were made with different types of spray nozzles and nozzle placements with a view to obtaining better spray coverage with conventional types of sprayer, particularly knapsack sprayers. A comparative assessment of the spray coverage obtained with a Helicopter, a High Clearance Tractor and Modified Knapsack Sprayer was also made.

TYPE OF SPRAY NOZZLE

Several types of spray nozzles giving the required output for low volume spraying of cotton have been tested, of which the Cone-Jet tips produced by Messrs. Spraying Systems Company, U.S.A., have been found to be very suitable. These nozzles, which give a fairly solid cone of spray have been used in all subsequent tests.

SPRAY NOZZLE PLACEMENT

Investigations have been carried out to assess the performance of various spray nozzle placements in relation to the cotton plant. These have shown that the most uniform spray coverage of the plant is obtained by having three nozzles on each side of the cotton row, spaced vertically, and directed to spray "up and under" through the plant.

MODIFIED KNAPSACK SPRAYER

The arrangement whereby six nozzles are directed to spray "up and under" through the cotton plants can be achieved easily with a high clearance mechanized sprayer fitted with a horizontal boom and drop arms. However, the bulk of the cotton in the Federation of Rhodesia and Nyasaland is grown in relatively small units

for which a knapsack sprayer is the most economical machine. It was found that a conventional knapsack sprayer could be suitably modified to carry the required number of nozzles in the correct position. The modification consisted essentially of a drop-arm or "tail boom" attached to the rear of the sprayer on which six spray nozzles may be positioned to give any desired direction of spray. A frame, attached to the rear of the spray tank, carries the tail boom, which is held at the top of the frame by means of a pin and at the bottom by means of a spring. The spring allows the boom to yield on meeting an obstruction, and by unfastening it, the boom can be raised to allow the sprayer to be placed upright on the ground. The tail boom is adjustable for height on the frame.

The spray nozzles are fed individually through PVC tubing from a central distributor and thus can be moved independently of each other on both vertical and horizontal planes. Cross arms on the boom allow the nozzles to be moved laterally. The frame, boom and cross arms are constructed of aluminium for lightness.

The spraying procedure is for the operator to walk between the rows of cotton. The spray is directed to each side, by nozzles previously adjusted for the growth of the crop.

A COMPARATIVE PHYSICAL ASSESSMENT OF THE SPRAY COVERAGE OF COTTON PLANTS, OBTAINED WITH A KNAPSACK, HIGH CLEARANCE TRACTOR AND HELICOPTER SPRAYER

A comparative physical assessment of the spray coverage of cotton plants was made, using a knapsack, high clearance tractor and helicopter sprayer. Details of the trial are given as follows:

EQUIPMENT

Knapsack Sprayer

Mysto K/GS/4 Knapsack Sprayer fitted with a tail boom having six Y4 Cone-Jet Spraying Systems Nozzles. Spraying pressure: 40 p.s.i. Application rate: 20 gallons/acre.

High Clearance Tractor Sprayer

"Hagie" High Clearance Tractor Sprayer, fitted with horizontal boom and drop arms. Each drop arm fitted with six Y4 Cone-Jet Spraying Systems Nozzles. Spraying pressure: 25 p.s.i. Application rate: 10 gallons/acre.

Helicopter Sprayer

A Hiller 12E Helicopter fitted with horizontal boom carrying 28D6 "Teejet" disc nozzles spaced one foot apart. Spraying pressure: 60 p.s.i. Application rate: 4 gallons/acre. Flying height: 5-6 feet off ground.

COTTON VARIETY

Assessments were made on two varieties of American Upland Cotton—Acala and CL20—selected because of their widely divergent growth characteristics. The mean height of the Acala and CL20 cotton were 42 inches and 63 inches respectively. The latter had more leaves and a denser type of growth than the former variety.

METHOD OF ASSESSMENT

A spray solution of Croceine Scarlet dye of known strength was used. Pinned table tennis balls were used as targets, on which the deposits of Croceine Scarlet dye was assessed colorimetrically.

RESULTS

Results are given in Table I. To facilitate comparison between the three sprayers involving different rates of application, the equivalent deposits have been determined assuming 1 lb. of insecticide was applied per acre in all treatments.

It will be seen that the overall variation in deposits is least with the knapsack sprayer. The lower variation in comparison with the tractor sprayer also using Y4 Cone-Jet nozzles can be explained by:

(1) The spray operator, by walking in front of the "tail boom" acts as a guard reducing the number of branches and leaves which brush against the nozzles. With unguarded drop arms, the spray is prevented from being distributed evenly, by plant material brushing against the nozzles.

(2) The distance between sets of nozzles on the drop arm was fixed and could not be adjusted according to plant height with the same degree of accuracy as for the knapsack sprayer.

(3) The lower pressure and thus a smaller spray angle is an additional factor, although perhaps of lesser importance.

In the CL20 cotton, disregarding the top of the stem, the variation in deposit was less with the knapsack sprayer (18 per cent.) than with the tractor (24 per cent.).

Good coverage of the Acala was obtained with the helicopter sprayer, but there was a marked drop in deposit down the CL20 plant in contrast with the other two types of sprayer. The air turbulence created by the helicopter, however, resulted in a fairly low variation of deposits within each target level.

(c) Field Insecticide Trials

The following field insecticide trials were carried out during the season:

1. *Relative Effectiveness of Endrin, Sevin and D.D.T.*

This trial was carried out to compare the relative effectiveness of various formulations and combinations of endrin, Sevin and D.D.T. in controlling cotton insect pests.

D.D.T., either alone or in combination with endrin or Sevin, was included primarily for the control of American Bollworm.

Applications were made at weekly intervals from first buds. Apart from the first two applications, when a lance fitted with two spray nozzles was used, spraying was carried out with up to six nozzles fitted to a hand boom, arranged to give optimum spray coverage. The dusts were applied using a Kestrel Knapsack Duster. A blanket treatment, of endrin or endrin+D.D.T., was included to give maximum control of cotton insect pests.

Details of the treatments, and yield data, are given in Table II.

All yields were very low owing to poor plant growth through lack of rain. However, it will be seen that all treatments which included Sevin tended to give the higher yields. The entomological data, showed that this resulted from Sevin giving the best control of *Diparopsis* larvae. The carry-over *Diparopsis* pupal population was also greatly reduced on all Sevin treatments. The *Heliothis* population was greatest on the endrin treated plots. There was little difference between Sevin and D.D.T. with regard to *Heliothis* control.

The blanket treatment did not keep the *Diparopsis* and *Heliothis* infestation at a negligible level as was hoped.

2. *Relative Effectiveness of different times of application*

This trial was carried out to determine the period over which applications of insecticide should be made, and the optimum interval between successive applications. The treatments, together with yield data, are given in Table III. Endrin, either alone or in combination with D.D.T., was used for the blanket treatment, endrin at $\frac{1}{4}$ lb. a.i. in 10 gallons for the remaining treatments, and the sprays applied as for Trial 1 above.

From the yield data, it will be seen that a reduction in the number of sprays, and an increase in the interval between successive sprays resulted in a lowering of yield.

3. *The Relative Effectiveness of Different Methods of Application*

This experiment yielded little or no useful information, owing to poor plant growth. The relative effectiveness of the different methods of application can only be adequately assessed on well-grown cotton, for it is when the plant becomes large and dense in growth that difficulties are encountered in obtaining adequate spray coverage. With the lack of rain, the plants remained stunted. Details of the treatment and yield data, however, are given in Table III.

4. *The Relative Effectiveness of Various Insecticides*

This trial was carried out to assess the relative effectiveness of endrin, WL1650, Thiodan, Seven, D.D.T. and Sevin+D.D.T. Details of the treatment and yield data are given in Table IV. The sprays were applied as for Trial 1.

All yields were very low, the highest being obtained with Sevin, either alone or in combination with D.D.T.

A Farm Scale Trial, as in previous seasons, was carried out, but this yielded little information owing to the very poor plant growth on many of the plots. This season, however, the sprayed plots were split into endrin and Sevin sprayed portions, and for those plots on which the growth of cotton was not too poor, the Sevin treated cotton out-yielded that treated with endrin.

Investigations in Other Areas of the Federation

CHITALA EXPERIMENT STATION, NYASALAND

During the 1959/60 season, *Diparopsis* pupation experiments were begun to determine the proportion of *Diparopsis* larvae forming overwintering pupae and the period of subsequent moth emergence. Full results will not be available until next season. *Dysdercus* records on alternate host plants were also made.

The main experiment was an insecticide trial in which different formulations of endrin, Sevin and D.D.T. were compared. Details of treatments together with yield data are given in Table V. The sprays were applied by means of a knapsack sprayer fitted with a lance having two spray nozzles, directed to spray "up and under" into the plants. Unfortunately, the Sevin spray treatment had to be discontinued, owing to the contamination of the insecticide with hormone herbicide. The plants developed severe "strap leaf" symptoms, and were greatly deformed.

All treatments gave significant increases over the control. Of the spray treatments, D.D.T. was more effective than endrin, through better control of *Heliothis*. In the case of D.D.T., sprays were more effective than dusts. It is interesting to note that Sevin dust was equally effective as a D.D.T. spray, and that in all probability a Sevin spray would be considerably more effective. The blanket treatment with endrin did not give a complete control, especially of *Heliothis*.

SABI VALLEY EXPERIMENT STATION

In an insecticide trial the following treatments were compared:

1. Blanket. Sprayed for a complete cover with endrin at a concentration of 0.025 per cent. for the first four applications and at 0.125 per cent. thereafter. 14 weekly applications.
2. Endrin. $\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre.
3. Sevin. 1 lb. a.i. in 10 gallons of water/acre.
4. D.D.T. 1 lb. a.i. in 10 gallons of water/acre.
5. Sevin. 5 per cent. dust applied at 20 lb./acre.
6. D.D.T. 5 per cent. dust applied at 20 lb./acre.

Treatments 2-6 were applied at weekly intervals from first buds, a total of eight applications being made.

There was no significant difference in yield between any of the treatments, all giving yields between 2,800 and 3,700 lb. seed cotton per acre.

Diparopsis pupation experiments and observations on alternate host plants of *Diparopsis*, *Earias* and *Platydra* and *Dysdercus* were carried out.

TABLE I

Comparative Assessment of Spray Deposit obtained by a Helicopter, High Clearance Tractor and Knapsack Sprayer

Sprayer	Nozzle data	Speed m.p.h. and output	Position of table tennis balls	Cotton Variety					
				Acala			CL20		
				Mean deposit*	Standard deviation	Coefficient of variation (%)	Mean deposit*	Standard deviation	Coefficient of variation (%)
Knapsack (fitted with tail boom)	6 × Y4† Conejet per row 40 lb./psi Angle 58°	1½ m.p.h. approx. 20 gals./acre	TS	1.55	0.19	12.3	0.72	0.24	33.3
			TB	1.79	0.26	14.5	1.60	0.26	16.3
			MS	1.84	0.12	6.5	1.56	0.34	21.8
			BB	1.89	0.09	4.8	1.89	0.32	16.9
			BS	1.69	0.21	12.4	1.82	0.25	13.7
			Mean	1.75	0.21	12.0	1.52	0.50	32.9
Hagie High Clearance Tractor Sprayer with boom and drop arms	6 × Y4† Conejet per row 25 lb./psi Angle 51°	2 m.p.h. 10 gals./acre	TS	1.33	0.31	23.3	1.65	0.30	18.2
			TB	2.07	0.26	12.6	1.93	0.56	29.0
			MS	2.04	0.12	5.9	2.25	0.49	21.8
			BB	2.13	0.15	7.0	1.86	0.41	22.0
			BS	1.96	0.16	8.2	1.75	0.31	17.7
			Mean	1.90	0.37	19.5	1.89	0.45	23.8
Helicopter	28 × D6 Teejet discs 60 lb./psi Angle 90° (30° swathe)	30 m.p.h. 4 gals./acre	TS	2.32	0.16	6.9	1.91	0.41	21.5
			TB	2.21	0.26	11.8	1.73	0.28	16.2
			MS	2.07	0.40	19.3	1.24	0.18	14.5
			BB	1.98	0.23	11.6	1.17	0.13	15.4
			BS	1.91	0.36	18.8	1.26	0.31	24.6
			Mean	2.10	0.32	15.2	1.46	0.41	28.1

KEY: TS=Top stem, TB=Top bud, MS=Mid stem, BB=Bottom boll, BS=Bottom stem

NOTES: * Mean deposit = $\text{Log } D + 6$ where D is the deposit of insecticide on a table tennis ball when all sprayers apply 1 lb. per acre irrespective of spray volume.

† The bottom set of nozzles was 8½" above the ground the 2nd- 23½" and the 3rd- 35½" in the Acala cotton and 8½", 23½" and 38½" in the CL20. The nozzles were directed upwards at an angle of 30°.

‡ The three sets of nozzles were 12" and 15" apart, the bottom set being 8½" and 14" above the ground in the Acala and CL20 respectively. The nozzles were directed upwards at an angle of 40°.

TABLE II
The Relative Effectiveness of Endrin, Sevin and D.D.T.
(Randomized Blocks. 4 Replicates)

<i>Treatment</i>	<i>Yield lb. seed cotton per acre</i>	<i>Per cent. damaged cotton</i>
1. Blanket*. 0.125% Endrin + 0.5% D.D.T. Sprayed to "run off". 12 weekly applications	449	1.6
2. Endrin. $\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre, 8 weekly applications	231	5.3
3. Sevin. 1 lb. a.i. in 10 gallons of water/acre, 9 weekly applications†	427	0.8
4. D.D.T. 1 lb. a.i. in 10 gallons of water/acre, 8 weekly applications	184	5.8
5. Sevin. 5% dust applied at 1 lb. a.i./acre, 8 weekly applications	344	1.6
6. D.D.T. 5% dust applied at 1 lb. a.i./acre, 8 weekly applications	154	5.9
7. 5 weekly applications of Treatment 3† followed by 4 weekly applica- tions of Treatment 5	344	2.8
8. 4 weekly applications of Treatment 4 followed by 4 weekly applica- tions of 10% D.D.T. + 3% BHC Dust‡	208	6.2
9. 4 weekly applications of Treatment 2 followed by 4 weekly applica- tions of 10% D.D.T. + 3% BHC Dust‡	224	5.2
10. 5 weekly applications of Treatment 3† followed by 4 weekly applica- tions of 10% D.D.T. + 3% BHC Dust‡	331	3.6
Least significant difference ($P=0.05$)	146	—

NOTES: * First three applications of blanket treatment made with Endrin only at a concentration of 0.025%

† The second spray application was repeated owing to heavy rain falling immediately after spraying had been completed.

‡ Cotton Dust (10% D.D.T. + 3% BHC), applied at the rate of 1 lb. D.D.T./acre, BHC was used for aphid control.

TABLE III
The Relative Effectiveness of Different Times of Application
(Randomized Blocks. 4 Replications)

<i>Treatment*</i>						<i>Yield lb. seed cotton per acre</i>	<i>Per cent. damaged cotton</i>
1.	Blanket†.	0.125% Endrin.	Sprayed to "run off".	13 weekly applications ..	..	819	0.3
2.	8 weekly applications	..	..	..	..	450	5.7
3.	2 early weekly applications followed by 3 late weekly applications					321	6.6
4.	4 fortnightly applications	..	..	..	..	287	8.8
5.	Applications made according to insect records. 9 weekly applications ..					652	2.5
6.	Applications made at night according to insect records. 9 weekly applications ..					595	2.9
Least significant difference (P=0.05)						17	—

NOTES: * All treatments, with the exception of the blanket treatment, sprayed with Endrin at $\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre.

† First two applications of blanket treatment made with Endrin at a concentration of 0.025%.

10th and 12th applications included 0.5% D.D.T.

13th application was 1 lb. Sevin in 10 gallons of water/acre.

TABLE IV
The Relative Effectiveness of Different Methods of Application
(Randomized Blocks. 4 Replications)

<i>Treatment*</i>		<i>Yield lb. seed cotton per acre</i>	<i>Per cent. damaged cotton</i>
1.	Blanket†. 0.125% Endrin. Sprayed to "run off". 12 weekly applications	616	1.0
2.	Hand spraying with double acting hand syringe. 1 × Y6 Conejet nozzle/row	532	2.8
3.	Knapsack Sprayer with hand lance. 2 × Y6 Conejet nozzles/row directed "up and under"	565	1.7
4.	Hand Boom with drop arms. 3 × Y2.5 Conejet nozzles/row‡ ..	422	2.7
5.	Hand boom with drop arms. 6 × Y2.5 Conejet nozzles/row§ ..	564	1.6
6.	Power Duster (Fontan Knapsack). Single row application ..	573	2.4
7.	Hand Duster (Kestrel Knapsack). Single row application ..	430	3.0
8.	Power Duster (Fontan Knapsack). Drift dusting over 3 rows ..	400	3.5
9.	Blanket†. Air blast spraying with Fontan Knapsack Sprayer. Single row application	348	5.1
10.	Air blast spraying with Fontan Knapsack Sprayer. Single row application	525	2.8
Least significant difference (P=0.05)		99	—

NOTES: * All treatments, with the exception of the two blanket treatments, sprayed with Sevin at the rate of 1 lb. a.i. in 10 gallons of water/acre. 8 weekly applications.

† First two applications of blanket treatment sprayed with Endrin at a concentration of 0.025%. 9th and 11th applications included 0.5% D.D.T. 12th application was 1 lb. Sevin in 10 gallons of water/acre.

‡ 1 nozzle directed downwards above the plant.

2 nozzles directed "up and under" into the plant.

§ 2 upper nozzles directed downwards and sideways into the plant.

4 lower nozzles directed "up and under" into the plant.

TABLE V

The Relative Effectiveness of Endrin, WL1650, Thiodan, Sevin, D.D.T. and Sevin+D.D.T.

(Randomized Blocks. 4 Replications)

Treatment (8 weekly applications)				Yield lb. seed cotton per acre	Per cent. damaged cotton
1.	Endrin.	$\frac{1}{4}$ lb. a.i. in 10 gallons water/acre	.. .. .	289	7.1
2.	Sevin+D.D.T.	$\frac{1}{2}$ lb. a.i. of each in 10 gallons water/acre	.. .. .	458	1.1
3.	Sevin.	1 lb. a.i. in 10 gallons of water/acre	.. .. .	444	1.4
4.	D.D.T.	1 lb. a.i. in 10 gallons of water/acre	.. .. .	264	6.3
5.	Thiodan.	$\frac{1}{2}$ lb. a.i. in 10 gallons of water/acre	.. .. .	361	6.2
6.	WL1650.	$\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre	.. .. .	277	9.1
Least significant difference				82	—

TABLE VI

The Relative Effectiveness of Endrin, Sevin and D.D.T.

(Randomized Blocks. 4 Replications)

Treatments				Yield lb. seed cotton per acre	Per cent. damaged cotton
1.	Blanket*.	0.125% Endrin sprayed to run off, 13 weekly applications	.. .. .	1,118	9.4
2.	Endrin.	$\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre. 10 weekly applications	.. .. .	795	12.3
3.	D.D.T.	1 lb. a.i. in 10 gallons of water/acre. 10 weekly applications	.. .. .	1,149	9.4
4.	Sevin.	1 lb. a.i. in 10 gallons of water/acre. 10 weekly applications	.. .. .	—	—
5.	D.D.T.	5% Dust applied at 20 lb./acre. 10 weekly applications	.. .. .	657	17.7
6.	Sevin.	5% Dust applied at 20 lb./acre. 10 weekly applications	.. .. .	1,029	8.5
7.	Control—unsprayed	.. .. .	.. .. .	318	36.8
Least significant difference ($P=0.05$)				259	—

NOTES: * 1st application of blanket treatment sprayed with Endrin at a concentration of 0.025%.

10th application sprayed with D.D.T. at a concentration 1% for *Heliothis* control.

NORTHERN RHODESIA

The main work in Northern Rhodesia consisted of a spraying trial, in which pairs of plots, one sprayed and one unsprayed, were laid out at Mount Makulu Research Station and in the Zambezi Valley, Tonga Plateau and Mumbwa areas. Apart from one sprayed plot which was sprayed with Sevin (1 lb. a.i. in 10 gallons of water/acre),

the spray treatment was $\frac{1}{4}$ lb. endrin in 10 gallons of water/acre. Applications were made at weekly intervals over a total period of eight weeks from first buds. A full analysis of this trial has yet to be made.

LOWER SHIRE RIVER AREA OF NYASALAND

An observation plot of cotton was selected at Ngabu and at Chikwawa in the Lower Shire River area of Nyasaland. The two plots, each approximately one acre in area, were divided, one half of each being sprayed with endrin at $\frac{1}{4}$ lb. a.i. in 10 gallons of water/acre, and the other half being left unsprayed. At Chikwawa, the cotton was well advanced at the start of spraying and only five weekly spray applications were made. At Ngabu, six weekly spray applications were made from first buds, followed by two weekly sprays of D.D.T. at 1 lb. a.i./acre for *Heliothis* control. Yield data was as follows:

Yield of Seed Cotton/Acre (% damaged cotton in brackets)

					<i>Sprayed</i>	<i>Unsprayed</i>
Ngabu	..	..	..	..	1,488 (19.8%)	978 (29.4%)
Chikwawa	..	..	..	..	1,412 (8.8%)	894 (17.7%)

A small insecticide trial was carried out at Makanga Experiment Station. Details of spray treatments and yield data are given below. Uneven plant growth reduced the sensitivity of the experiment.

<i>Treatment</i>					<i>Yield of s.c./acre</i>	<i>% damaged cotton</i>
1.	Control—unsprayed	..	..	..	767	26.6
2.	Blanket—13 applications of 0.125% Endrin	..	..	..	1,444	8.4
3.	Sevin—eight applications of 1 lb. a.i. in 10 gallons of water/acre	..	..	..	1,121	8.9
	Least significant difference	..	..	..	423	—

Summary

Considerable progress was made in most of the investigations, although adverse weather conditions resulted in poor growth of the cotton and thus reduced the amount of information obtained from the field trials.

At intervals during the season, observations were made on the behaviour and natural mortality of *Diparopsis* from egg to emergence from the soil as an adult moth. The availability of food, climatic conditions and the lack of predators resulted in certain differences when compared with the previous season.

The level of egg mortality was lower than in the previous season, the differences being attributed to the lack of predacious ants and to the low rainfall of the 1959/60 season.

Preliminary observations of a similar nature were made on *Heliothis*.

Pupation experiments showed that the period of moth emergence from overwintering pupae in fallow land was distinctly later with two definite peaks. Pupal development was suppressed at a temperature of 55°F, and continued to be suppressed after the pupae were transferred to 65°F whereas pupae transferred from 55–75°F recommenced development normally. Pupae at a depth of 4–8 inches in the soil emerged earlier than pupae at 0–4 inches in the soil.

In addition to the toxicity studies and field trials, progress was made in the study of spray application, following which a modification aimed at providing improved spray coverage of cotton was designed to fit knapsack sprayers.

Although yields in the field trials were low, the entomological data showed that Sevin gave the best control of *Diparopsis* larvae, and that the overwintering *Diparopsis* pupal population was also greatly reduced.

Work at other experiment stations in the Federation was increased and provided valuable data for comparison with the basic studies at Gatooma and Makanga.

Investigations at Makanga Experiment Station, Nyasaland

INVESTIGATIONS ON DYSDERCUS SPP.

Unfavourable climatic conditions from November to January were again the basic cause of low *Dysdercus* populations. Planting rains were late and some resowing was necessary, but once the plants were established conditions were very suitable for growth and a good crop was obtained. Although a record amount of seed-cotton was harvested this was due largely to a considerable increase in acreage sown rather than to any great increase in average yield.

Routine records were continued. *Dysdercus* populations were sampled on both their alternate hosts and on cotton, and the survey of alternate hosts was extended to Chikwawa area.

Dysdercus intermedius was recorded as feeding on the seeds of *Deinbollia xanthocarpa* (Klotz), both nymphs and adults being present, but this tree is not regarded as a true host. It is hoped to confirm this next season.

ENUMERATION OF HOST-TREES

In an area centred on Sorgin of approximately 79 square miles all the *Sterculia africana* were cut down for an experiment (see below). The number of trees cut down averaged 49 per square mile. In a second sample area near Chiromo of 16 square miles an average of 51 *S. africana* was found. On the basis of these two sample counts, supposing an average of 50 trees per square mile for the whole of the Lower River region (approximately 1,500 square miles), some 75,000 *S. africana* occur in the Lower River.

Two other host trees were enumerated at the same time for these two areas, as follows:

Trees per square mile				Sorgin	Chiromo
<i>Sterculia appendiculata</i>	..	..	..	13	16
<i>Adansonia digitata</i>	..	..	..	13	19

The enumeration is being continued in other sample areas.

LONG-TERM EXPERIMENT ON THE EFFECT ON DYSDERCUS OF CUTTING DOWN THE MAJOR PRE-COTTON ALTERNATIVE HOST, THE TREE STERCULIA AFRICANA

This is the second full season of this experiment. The experimental layout was as given in the 1958/59 Part II Report. Table VII gives a summary of the populations of *Dysdercus* each month on cotton fields.

TABLE VII
Summary of Dysdercus Population Records, Sorgin Experiment
 NUMBER OF ADULTS PER ACRE

Month					Area A	Area B	Area C	Area D	Area E
March ..	..	..	..	..	76	50	46	71	61
April ..	..	..	..	..	189	215	75	105	77
May ..	..	..	..	..	140	246	183	244	213
June ..	..	..	..	..	203	274	984	452	708

FIFTH INSTAR NYMPHS PER ACRE

March ..	..	..	..	..	4	5	5	8	1
April ..	..	..	..	..	54	72	69	71	20
May ..	..	..	..	..	99	96	1,021	1,091	347
June ..	..	..	..	..	150	221	2,270	3,577	1,955

APPROXIMATE NUMBER OF YOUNG NYMPHS PER ACRE

March ..	..	..	..	..	12	3	5	2	2
April ..	..	..	..	..	330	500	400	2,000	140
May ..	..	..	..	..	500	600	6,000	6,000	5,000
June ..	..	..	..	..	500	300	19,000	12,000	40,000

At this stage it is not possible to come to any conclusion on the figures available for the two seasons; what is required is a season that is favourable to *Dysdercus*, particularly during the pre-cotton months. However, a third season's results may enable tentative conclusions to be reached even if a poor year for *Dysdercus* occurs.

The yield per acre was very variable and yields of between 240 and 2,030 lb. seed-cotton per acre were obtained from individual one-tenth acre plots. Seventeen of the forty plots gave over 1,000 lb. seed-cotton per acre, while ten of the plots gave less than 500 lb. This variation was due chiefly to agronomic factors and to a lesser extent to insect pests.

Area E was outside the experimental area, Area A was in the centre of the experimental area with B, C and D at progressively greater distances from the centre.

TABLE VIII
Yields per Acre from the Areas of the Sorgin Experiment

Area*						Grade I	Grade II	Total	Per cent. Grade II
A ..	..	..	..	..	..	714	196	910	21.5
B ..	..	..	..	..	..	709	176	885	19.9
C ..	..	..	..	..	..	557	175	732	23.9
D ..	..	..	..	..	..	955	257	1,212	21.2
E ..	..	..	..	..	..	591	210	801	26.2

* Each area represents 8 plots on a circle, a total of four-fifths of an acre.

DESTRUCTION OF ALTERNATE HOSTS

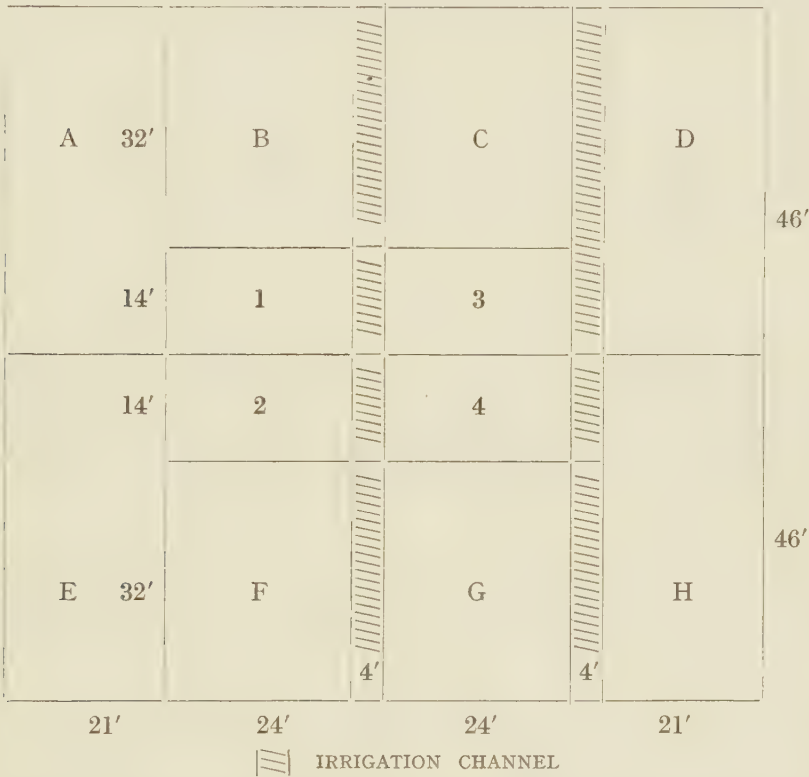
It has been found that ring-barking alone is sufficient to kill *Sterculia africana* and that, while some arboricides hasten the progress, the use of chemicals is unnecessary. It was found that ring-barking plus an application of MCPA 2, 3, 6-Trichlorobenzoic acid (sodium salt) on the cut surface usually caused the tree to fall inside a

year and active growth to cease in a few months. Ring-barking alone caused death usually within two years, but in extra large trees death might not occur for three years although no fruiting is likely to occur in the second year.

EXPERIMENTAL CAGES FOR THE FIELD STUDY OF COTTON INSECTS

Four field cages were constructed at Makanga Farm and completed in November, 1959. Dexion supports set in a low cement-block wall were used to support the Tigan plastic mesh which was bolted between the Dexion and wooden slats. Provision was made for irrigation, a cement channel passing through each cage extending from the existing irrigation system on the farm.

Each cage is 14 × 28 feet in area and 10 feet high; the cages were built as a block to save cost and add to the rigidity. The construction was on a part of the farm that had not been under cotton the previous season and the soil, lightly broken up by hoeing, was inspected for insects, any found being removed prior to planting. The cages were situated in the midst of other plots of cotton (*see* Diagram).



In this first season the intention was to discover if a crop could be obtained at all under the artificial conditions, and to study known populations of *Dysdercus intermedius* on an otherwise pest-free crop.

Forty *D. intermedius* adults were released in Cage 2, and one thousand in Cage 3, the sex ratio being approximately 1:1. The two other cages were free from insects. Forty was a number regarded as representing a high initial infestation, equivalent to about 4,500 adults per acre, while 1,000 is equivalent to an infestation of some 112,000 adults per acre, a number far greater than ever recorded on cotton in this country in February–March in the field. Initial infestations occurring naturally on cotton have not exceeded a mean of 100 per acre for the past three years at least.

The breeding rate, mortality and damage done by *D. intermedius* was recorded, and observations were made on their behaviour. Grades and yields of the cotton were recorded.

Planting

Single plant per hole, 3 feet $\times$ 2 feet spacing, 32 plants per cage, unridged soil. No irrigation was used. Albar 637 was planted. All the cotton, in the cages and in the outside plots, was sown on 29/12/59. Some supplying was necessary and this was done on 7/1/60 and 13/1/60. Cages and plots were clean weeded throughout.

Growth

Plant height records were kept on five plants per cage (twenty plants in all) and five plants on four of the plots (twenty plants in all). The mean heights are given below:

TABLE IX
Mean Heights of Cotton Plants in Inches

Date					Inside cages	Outside plots
13/2	..	..	..	..	30.7	23.8
19/2	..	..	..	..	35.4	25.3
26/2	..	..	..	..	45.7	32.4
5/3	..	..	..	..	55.5	37.7
11/3	..	..	..	..	62.8	42.0
18/3	..	..	..	..	68.8	46.2
25/3	..	..	..	..	74.0	51.0
1/4	..	..	..	..	80.5	55.5
8/4	..	..	..	..	85.7	58.0
14/4	..	..	..	..	88.25	60.0

Growth virtually ceased on this date except for the plants in Cage 3 which continued to grow and attained a mean height (five plants) of 115.2 inches on 21/5/60. Cage 3 had considerably more shade than the other cages due to the other cages shielding it from the sun for much of the day.

General observations

Some trouble was experienced in the cages from cutworm (*Euxoa setigerum*), a few of which appeared when the plants were seedlings despite the preliminary search for insects prior to planting. These were removed by hand and no further occurrence took place.

Towards the end of February a very considerable multiplication of aphids (*Aphis gossypii*) and coccids (*Ferrisiana virgata*) occurred and threatened to destroy the plants. Both these species were on the plots outside the cages but in much smaller numbers, and first appeared in the cages in January. Collections of Coccinellidae were made, however, chiefly of *Cheilomenes propinqua*, *C. sulphurea* and *Exochomus* sp., and these were released in the cages. Within a week there was a considerable improvement and the plants suffered no serious set-back. The beetles bred in the cages without further attention and kept the Homoptera under control for the rest of the season.

In early May very large numbers of migrating *Dysdercus* adults gathered outside the mesh of the cages, apparently arriving from nearby cotton fields. Numerous adults remained around the outside of the cages for the rest of the season. Adults in the cages appeared more numerous on the mesh at the same time, giving the impression that they were trying to get out at the time those outside were trying to get in. At

about the same time, too, large numbers of adult *Phonoctonus nigrofasciatus* appeared on the outside mesh. These laid numerous eggs on the mesh and fed on the *Dysdercus* outside the cages, reducing their number noticeably. At one stage the ground outside the cages was littered with the sucked dry bodies of *Dysdercus*.

None of the first-instar nymphs of *P. nigrofasciatus* were noted to find their way into any cage, but there was some movement between second-instar *Dysdercus* in the cages and outside the cages since these were able to pass through the mesh. It is not thought that many entered or left the cages, however, and there was no greater movement into the cages than there was out of the cages. The odd nymph sometimes turned up in one of the cages free from *Dysdercus* but these were very few and were killed on sight.

In May a few Red Bollworm (*Diparopsis castanea*) larvae made their appearance in Cage 3. When found most of these were first- or second-instar larvae, but two later instar larvae and one fifth-instar larva were found. They were removed from the cage as found and the numbers were much too small to have any significant effect on yield. It is thought that these larvae migrated through the mesh from the cotton outside when in their first-instar.

Considerable termite activity (*Odontotermes* and *Microtermes*) was noted at the beginning when a few seedling plants were damaged (one of the causes of supplying in January) and numerous tunnels were formed on the cages themselves. However, brushing down the earthen tunnels when seen prevented any serious damage to the mesh or woodwork, and Dieldrin was used where the most persistent activity was found. Care was taken when using the insecticide that no contamination of the soil in the cages was possible.

A very few *Laphygma exempta* larvae which found their way into Cage 3 in April were destroyed. The only other serious insect activity was a small amount of damage to the mesh itself by orthopterous insects chiefly occurring at night. Crickets and others very occasionally chewed a hole in the mesh. Such holes were patched or sewn up. Wind, however, was a much more serious cause of damage, and high winds caused the plastic mesh to split. The mistake was made when erecting the cages of stretching the mesh too tautly so that the stresses and strains caused strands to break. Guying the outside uprights helped to lessen the strain considerably but there is still too much movement in the structure.

White Flower Tagging

The fate of the white flowers of one plant in each cage, and on five plants outside the cages, were taken with the following results:

TABLE X
Fate of White Flowers

Cage No.	Total flowers	Total sheds			* Total bolls on plant damaged			Total clean	* Total per cent. damaged
		Bwms.	Dysd.	Others	Bwms.	Dysd.	Others		
1	98	—	—	31	—	—	4	63	36
2	76	—	—	26	—	10	2	38	50
3	87	—	—	46	2	28	6	5	94
4	63	—	—	9	2	—	1	51	19
B	26	8	—	5	9	1	1	2	92
C	57	3	—	10	21	12	5	6	89
F	33	14	—	7	6	2	4	—	100
G	56	11	—	11	12	8	1	13	77

Numbers 1 to 4 are the cages; B, C, F and G are the plots outside the cages.
 * Includes bolls only partially damaged. If a boll was damaged due to several causes the most severe agent only was recorded.

It should be noted also that the total flowers produced by caged plants was nearly twice that produced by uncaged plants (a mean of 81 on four caged, opposed to a mean of 43 on four uncaged plants). There is no indication to show that the presence of *Dysdercus* in a cage reduces the numbers of flowers formed or that stainers cause shedding, but there was a considerable loss in yield due to abortion of green bolls by *D. intermedius*. As much, if not more, loss occurred apparently due to physiological shedding.

Table XI below shows the weights of the cotton from the four plants in cages and the five plants not in cages, that were used for the white flower fate records.

TABLE X
 Yields from Tagged Cotton Plants (in grams)

Cage or plot				Grade I	Grade II	Total
1	..	..	..	243	4	247
2	..	..	..	157	40.	197
3	..	..	..	36	15	51
4	..	..	..	209	2	211
B	..	..	..	9	12	21
C	..	..	..	38	46	84
F	..	..	..	3	12	15
G	..	..	..	54	24	78

Shed Collections

Weekly shed collections were made from each of the cages during the period of bud and boll production. Table XII gives the total record for 13 weeks from 11/3/60 to 2/6/60.

TABLE XII
 Shed Analysis, Experimental Cages and Plots

Cage/plot				Shed buds		Shed green bolls		Shed split-bolls		Totals	
				damaged	clean	damaged	clean	damaged	clean	damaged	clean
1	..	..		2	318	2	2,204	—	16	4	2,538
2	..	..		—	340	4	2,536	—	10	4	2,886
3	..	..		20	306	16	2,994	4	44	40	3,344
4	..	..		2	566	2	1,784	—	18	4	2,368
B	..	..		676	204	623	1,078	12	11	1,311	1,293
C	..	..		677	300	706	1,046	5	17	1,388	1,363
F	..	..		623	362	1,056	1,233	21	26	1,700	1,621
G	..	..		890	239	976	899	39	54	1,905	1,192

The area and number of plants of each plot was approximately double that of each cage; the sheds recorded from the plots have been doubled, therefore, in the above table to give a greater comparison. The table shows that there was a great amount of physiological shedding in the cages and the plots but was considerably higher in the cages, presumably due to the different conditions of growth. In the cages the total number of undamaged sheds almost equals the total number of undamaged plus the total number of damaged sheds in the plots. No shedding in the cages infested by *Dysdercus intermedius* could be attributed to that insect; the higher total shedding in Cage 3 was thought to be due to greater shading in this cage. The high number of damaged sheds on the plots was largely due to *Diparopsis castanea*.

Breeding of D. intermedius in the cages. In both artificially infested cages (Cages 2 and 3) three generations were bred on the crop, and the first-instar nymphs of the F3 generation occurred about 8/6/60.

The breeding of the first generation took about 42 days from egg to adult, while that of the second generation took approximately 45 days. That of the third generation was not possible to determine exactly but was thought to take about the same period.

The total numbers of dead specimens retrieved from the cages during the course of the experiment are shown below:

					<i>Nymphs</i>		<i>Adults</i>		<i>Total</i>
<i>Cage 2</i>	..	..	..	..	12	..	91	..	103
<i>Cage 3</i>	..	..	..	..	37	..	1,787	..	1,824

The record of those still alive on 9/7/60 was:

					<i>Young nymphs</i>		<i>Fifth-instar nymphs</i>		<i>Adults</i>		<i>Total</i>
<i>Cage 2</i>	..	..	..	..	80	..	40	..	634	..	754
<i>Cage 3</i>	..	..	..	..	731	..	290	..	3,025	..	4,046

Initially 40 adults were released in Cage 2 and 1,000 in Cage 3. Thus the following numbers were produced in the season:

Cage 2: 685 adults plus 132 nymphs, or about 17 times the original population.

Cage 3: 3,812 adults plus 1,058 nymphs, or about 4 times the original population.

This indicates that the breeding rate of the higher population in Cage 3 was considerably lower than that of Cage 2, possibly due to over-population. It has been noted already that populations of the magnitude of that in Cage 3 have not been seen in the field.

The table below (Table XIII) shows the yields per acre and grades from the cages and the plots. The yields in the cages were considerably in excess of the yields on the outside plots.

TABLE XIII
Yields and Grades from the Cages and Plots (lb. per Acre)

<i>Cage/plot</i>					<i>Grade I</i>	<i>Grade II</i>	<i>Total</i>	<i>Per cent. Grade II</i>
1	..	..	..	..	1,805	—	1,805	—
2	..	..	..	..	1,666	305	1,971	15.5
3	..	..	..	..	611	1,000	1,611	62.1
4	..	..	..	..	1,916	—	1,916	—
A	..	..	..	..	451	417	868	48.0
B	..	..	..	..	312	198	510	38.8
C	..	..	..	..	85	241	326	74.0
D	..	..	..	..	169	395	564	70.0
E	..	..	..	..	327	293	620	47.2
F	..	..	..	..	184	241	425	56.7
G	..	..	..	..	298	255	553	46.1

It is intended to repeat this experiment with the cages next season. With further information it should be possible to form some valid conclusions.

BIOTIC CONTROL OF DYSDERCUS

Further experiments were made with *Phonoctonus nigrofasciatus* in the control of *Dysdercus*. These were again inconclusive due to the small numbers of the host insects available this season in the field.

MARKING EXPERIMENTS WITH *DYSDERCUS*

Experiments marking *Dysdercus* adults for recovery were made in previous seasons but without much success. Adults were marked with spots of paint of different colours and patterns, so that any individual adult could be identified again. This method was tedious and insufficient numbers could be marked, so that very few specimens were recovered.

Laboratory tests have now been made with various dyes using the dusting method described by Macleod and Donnelly (*Bull. ent. Res.* 48:587) in 1957. This has been found highly successful with *Dysdercus* adults and even when the insects were washed in water after dusting positive results were obtained. It is hoped that field trials will be possible this coming season.

SUMMARY

Estimates of the populations of the main arboreal hosts of *Dysdercus* are given for the Lower River.

Further data are given on the effect on cotton-stainers, mainly *Dysdercus intermedius*, of cutting down the major pre-cotton host, *Sterculia africana*. The evidence is inconclusive to date.

Ring-barking alone will kill *Sterculia africana*, the main arboreal host of *Dysdercus*.

Cotton was grown in four large field cages with the object of studying the plant and known populations of one pest (*Dysdercus intermedius*) and its effect on the crop. *D. intermedius* were released in two cages, 40 in one cage and 1,000 in another, the two remaining cages being free from insects.

It was discovered that a normal cotton crop was possible to obtain under caged conditions, although the cages produced an environmental effect that differed from that of the plots outside the cages. The most noticeable effect on the plants was in the rate of growth in and outside the cages and a greater flower production.

The most serious condition created in caged plants was a very numerous attack of coccids and aphids. This was brought and kept under control in a very short time by the introduction of Coccinellidae.

No shedding in the cages infested by *D. intermedius* could be attributed to that insect, and this confirms previous evidence to show that *Dysdercus* spp. do not cause shedding in the Lower River.

In all four cages the total number of undamaged fruiting points shed almost equalled the total number of undamaged plus the total number of damaged sheds in the uncaged plots.

In the cages infested by *D. intermedius* at both levels of infestation, three generations were bred on the crop, the lower initial population of 40 adults producing 17 times the original population, the higher initial population of 1,000 adults producing only four times the original population. Forty adults in a cage is equivalent to about 4,500 per acre, while 1,000 adults is equivalent to some 112,000 per acre.

The yields of seed-cotton in the cages were very much in excess of yields on uncaged plots.

Low numbers of *Dysdercus* in the field accounted for inconclusive results in experiments with *Phonoctonus nigrofasciatus* as a control.

Experiments marking *Dysdercus* adults for recovery have so far met with little success in the field.

TEA

Joint Tea Research Committee

<i>Chairman</i>	..	R. W. KETTLEWELL, C.M.G., B.SC. (Reading), DIP. AGRIC. (Cantab.), A.I.C.T.A., Secretary for Natural Resources.
<i>Members</i>	..	Messrs. J. F. RAMSDEN, B.A., R. R. A. BISHOP, A. N. HEARN, A. R. WESTROP, B.SC., J. S. BARR, and A. M. CADMAN, M.B.E., all appointed by the Tea Association of Nyasaland and Rhodesia. The Chief Agricultural Research Officer and Senior Agricultural Chemist representing the Nyasaland Government. The Director and Plant Breeder of the Tea Research Stations.

Resident Scientific Staff

<i>Director</i>	..	..	..	D. H. LAYCOCK, M.SC. (Leeds), A.I.C.T.A.
<i>Agronomic Section</i>	..	..	..	D. H. LAYCOCK, G. A. BRIDGER, G. F. CRASKE, N.D.A., C.D.A.
<i>Plant Improvement Section</i>	..	..	..	R. T. ELLIS, B.SC. (Lond.), DIP. AGRIC. SC. (Cantab.), Plant Breeder, I. P. SCARBOROUGH, DIP. HORT. (Nottingham), Horticulturist.
<i>Laboratory and Field Assistants</i>	..	..	..	J. P. MSAYA, D. M. WILLIE, P. M. O. MBISA, D. L. CHIMWALA, C. W. NDOVE, J. H. KATHUMBA, H. MSAYA, F. E. MPOTHA, G. WINDOW and H. S. KHONYONGWA.

Department of Agriculture Non-Resident Staff Partially Concerned with Tea Experimental Work

<i>Chief Agricultural Research Officer</i>	..	..	..	S. T. HOYLE, O.B.E., M.A. (Cantab).
<i>Senior Agricultural Chemist</i>	..	..	..	C. V. CUTTING, B.SC., PH.D. (Lond.) F.R.I.C.
<i>Soil Physics</i>	..	..	..	R. A. WOOD, B.SC. (Manch.).
<i>Laboratory Technician</i>	..	..	..	R. C. PEAK.

Associated Research at Cambridge University

<i>Biochemist</i>	..	..	..	D. S. BENDALL, PH.D.
-------------------	----	----	----	----------------------

Senior Clerical Staff

T. H. K. MZEMBE and S. W. KAPUNGWA

Leave and Appointments, Senior Scientific Staff

D. H. LAYCOCK	..	..	..	U.K. leave August to October, 1959.
R. T. ELLIS	..	..	..	Appointed Plant Breeder with effect from January, 1960.

Acknowledgments

All established estate experiments carried on satisfactorily throughout the season and to the Managers concerned we again offer our very grateful thanks for their continued interest. Two new estate experiments were started in Cholo and our thanks are due to Messrs. Brewer and Newby for their co-operation.

We also wish to thank the Director of Agriculture and his staff for the help that has been given in various ways and for the facilities that have been made available.

Introduction

Unless otherwise stated this report refers to the crop season July, 1959, to June, 1960. Throughout, the labour supply was adequate for all purposes.

In complete contrast with the previous season, the one under review has seen the stations change once again into full activity. With the arrival in January of Mr. Ellis, Plant Breeder, the Senior Scientific Establishment was completed and the Plant Improvement section is at last in full swing. Methods of growing cuttings through the nursery stages have progressed and we are now at the stage where useful advice can be given to the industry.

No new major long term field experiments were laid down during the year but plans and preparations are being made for a series of new experiments to be planted during the coming rains. Five are connected with the plant improvement programme. The established field experiments carried on in their unglamorous way and it was possible half way through the year to begin the long delayed job of collating much data collected over previous years. For a start, attention was given to spacing, with pleasing results, and a summary of these is included in this report.

Clearing and development continued on the new station in Cholo and the first experiments are scheduled to be planted there in December, 1960. The immediate building programme is completed.

The Tea Research Committee met five times and was enlarged by two representatives from Rhodesia. Preliminary attention was given to Rhodesian requirements for experimental work. At the request of the Committee a comparative ecological and soil survey was made between the Nyasaland and Rhodesian tea areas.

The most important development during the year was the take-over on 1st November, 1959, of the stations and staff from Government by the Tea Association and to meet the added expenditure the Nyasaland industry increased the cess paid on production. All senior and junior staff transferred with the exception of two senior clerks who preferred to remain in Government service.

In summary, a good and vigorous season which appears to herald a productive future in contrast to the frustrations of the previous season.

AGRONOMY SECTION

Soil Moisture Studies

(i) SOIL MOISTURE MOVEMENTS UNDER MATURE UNSHADED TEA, SWAZI

Readings from gypsum blocks were taken at weekly intervals throughout the season. Blocks are now in place at intervals to 17 feet 6 inches below soil level. Period gravimetric samples were taken in support of the block readings. Penman calculations have been made, using meteorological data from the Mimosa site and anemometer readings from the actual plots. It was hoped that by the end of the season to present a quantitative picture of moisture movements in relationship to climate but difficulties have arisen and these cannot be resolved until the return of the Soil Physicist from America.

At the beginning of the 1959 dry season the profile was at field capacity and drying out followed. By the end of October under unpruned tea the soil had dried to wilting point to a depth of 10 feet and considerable drying had taken place at the 15 feet and 17 feet 6 inches depths. Meanwhile, as expected, the pruning had delayed moisture usage although drying at all depths was evident at the end of October.

Good showers in November and December began to replace moisture reserves but the profile to 17 feet 6 inches was not filled until March, 1960. By April, drying out of the top 3 feet was evident and by June the 5 foot layer was affected.

The gypsum block readings taken together with rainfall quantities suggest that wetting at depth with consequent replenishment of the water table has been poor since the 1957 drought. Decreasing stream flows and decreasing amounts of water in tube wells support this contention and some fear is felt for water reserves in the tea areas at the end of the 1960 dry season. Above average quantities of rain will be necessary during the next wet season to alleviate the position.

(ii) SOIL MOISTURE MOVEMENTS UNDER YOUNG TEA WITH AND WITHOUT INTERPLANTED SHADE TREES

Gypsum blocks were sunk at 1 foot, 5 feet and 10 feet depths May, 1958, under each of the sub-plots in the shade tree experiment. There are four shade treatments: no shade, *Albizzia gummifera*, *Grevillea robusta* and *Glyricidia maculata*. (A more detailed description of the experiment with tea yields is given later in this report.)

Block readings began in mid-June, 1958, and have continued at weekly intervals thereafter. Moisture movements according to shade treatments at the end of each month are plotted on Fig. 1 and each reading for each shade treatment is the mean of 16 blocks at each depth. The tea was 8.5 years old from transplanting at the end of June, 1960, and the shade trees a year younger. Superimposed on the shade treatments are fertilizer rates but these have had no evident effect on moisture movements.

At 1 foot there are no pronounced differences in moisture reserves between shade treatments. The curves reflect drying out in the 1958 and 1959 dry seasons and filling with the intervening main rains. The 1960 dry season saw good rainfall quantities and distribution until the end of September; consequently, and in contrast with the previous dry seasons, little drying had taken place up to the end of September.

At both the 5 and 10 foot depths the blocks indicate that *Albizzia gummifera* had a more pronounced depleting effect on moisture reserves than *Grevillea robusta*, *Glyricidia maculata* and no shade. There are no obvious differences between the latter three shade treatments.

Shade treatments have had significant effects on yields and these are reported later.

(iii) GENERAL

Gypsum blocks have been placed under the following experiments or observational plots during the season but there is insufficient data for report as yet:

- (a) Two irrigation experiments in the Southern Province,
- (b) Shelter belt observational plots,
- (c) One pruning experiment,
- (d) Various water and soil conservation plots,
- (e) Two irrigation observations in the Northern Province.

During the year the Director was appointed to the Protectorate's Hydrological Co-ordinating Committee and attended the East African and Federal Hydrological Conference held in Blantyre.

Pruning Experiments

(i) LENGTH OF PRUNING CYCLE AND TYPE OF PRUNE, SWAZI

This experiment completed its nineteenth successive year and a full report was given last season. Reports are made every third year to fit in with the three year pruning-cycle and consequently no data are offered this year.

(ii) PRUNING CYCLES ON LOCAL JAT TEA, THORNWOOD ESTATE

A detailed progress report on the first six seasons' results from this experiment was published in *Tropical Agriculture* (Trinidad), volume 37 of 1960, pp. 125-134.

At the end of the season under review the experiment had completed eight successive seasons of treatments. Only the annually pruned plots were pruned, the two and three yearly cycles being unpruned and in their second year from prune. Yields for the past season and average yields per year for the eight seasons are given in Table I.

TABLE I
Yields in lb. m.t.p.a. according to pruning cycles, Thornwood Estate

Cycle	Yearly	2 yearly	3 yearly	L.S.D.	
				0.05	0.01
1959/60 season	868	722	767	114	155
Average per season over 8 seasons	1,054	1,042	1,061	115	157

C.V. % 1959/60, 20.97 C.V. % 8 seasons, 15.83

During the year the annually pruned plots have yielded significantly more than the two yearly cycle ($P=0.05$); there are no other significant differences. No significant differences occur between yields averaged over eight seasons.

Straightforward yields as presented above miss the most important indications of this experiment; those of the interplay between pruning cycle and nitrogen rate. Gradually, as the years progress, the interplay becomes more pronounced and although not yet statistically significant, the linear $\times$ linear component of the sums of squares of the interaction becomes increasingly large and at the end of the eighth year accounted for 88.96 per cent. of the total.

The interplay is shown in Table II.

TABLE II

Average yearly yield for 8 seasons according to length of pruning cycle and nitrogen rate

Pruning cycle					Nitrogen lb. N. p.a.		
					40	80	120
Yearly	..	..	..	..	830	1,035	1,296
2 yearly	..	..	..	..	766	1,015	1,346
3 yearly	..	..	..	..	703	1,078	1,403

The lowest nitrogen rate is not sufficient to support extended cycles and loss in yield occurs as the cycle is lengthened. In contrast, the highest nitrogen rate has caused increasing yields as the length of cycle increases. At 80 lb. of nitrogen per acre there is little difference in yields. This result suggests that the minimum nitrogen rate to support an extended cycle is 80 lb. per acre and that higher yields still can be expected from a combination of higher nitrogen and a three year pruning cycle.

(iii) EFFECT OF TYPE OF PRUNE ON THE YIELDS OF YOUNG TEA

In the 1958/59 Annual Report a note was made under the section dealing with N.P.K. applications on young tea that the fertilizer experiment was to be increased in scope by including two different pruning methods. These are to give the usual clean-prune at the desired height and, in contrast, to prune at the same height but with no-cleaning thereafter. The possible advantages of the latter method were suggested by the first six seasons' result from the Thornwood Local experiment and by 18 years' results from the Swazi "Type of Prune" experiment.

During the first season significant differences were caused by the pruning treatments as can be seen in Table III.

TABLE III

Effect of pruning method on the yield of young tea, lb. m.t.p.a.

					Pruning method		L.S.D. P=0.05
					Clean	No clean	
Yield 1959/60	..	..	..		1,063	1,163	76

C.V.% 1959/60, 8.95

The lighter type of prune has caused a significant increase in crop. Tipping height was the same for both types of prune. There was no significant interaction with fertilizer treatments.

Tipping Experiments

TIPPING LOCAL JAT TEA, THORNWOOD ESTATE

For the eighth consecutive season no significant differences in yields have been caused in total season crop by tipping at 2, 4 or 6 inches above the pruning cut.

Fertilizer Experiments

This section deals with fertilizers applied to unshaded tea planted at one spacing in any one experiment. The interplay of fertilizers with other management methods is reported elsewhere.

(i) N.P.K. EXPERIMENT ON YOUNG INDIAN TEA, MIMOSA

This experiment was planted in 1953 and had increasing rates of fertilizers applied annually until the planned maximum quantities were given for the first time this season.

These were:

- (i) Sulphate of ammonia supplying 40 or 80 lb. N. per acre.
- (ii) Single superphosphate supplying 0 or 30 lb. P_2O_5 per acre.
- (iii) Muriate of potash supplying 0 or 30 lb. K_2O per acre.

There were no significant differences in yield caused by these fertilizers.

(ii) THREE-CUBED FACTORIAL N.P.K. ON MATURE INDIAN TEA, SWAZI (MLANJE), AND NAMIREME ESTATE (CHOLO)

These two experiments have identical fertilizer treatments on equivalent tea but differ in that one is in the wetter Mlanje District and the other in drier conditions in Cholo. The experiments compare, in factorial combination, three levels each of the three major fertilizers. Yields according to treatments are given in Table IV.

TABLE IV
Effect of N.P.K. on yields of mature tea at Swazi and Namireme, lb. m.t.p.a.

Nutrient lb. per acre	N			P_2O_5			K_2O			L.S.D.	
	40	80	120	0	30	60	0	30	60	0.05	0.01
Swazi lb. m.t.p.a. ..	850	1,185	1,468	1,142	1,154	1,207	1,165	1,172	1,166	76	104
Namireme lb. m.t.p.a. ..	310	420	474	401	411	392	393	403	403	51	69

C.V.% Swazi, 9.44
C.V.% Namireme, 18.37

The yield and C.V. percentage at Swazi are near average but at Namireme yield is below average and C.V. percentage above, due to a dry year and a poor crop season. In both experiments increasing nitrogen rates have caused significant increases in yield.

At Namireme, under drier conditions, there was a pronounced proportionate falling off in response between the two higher rates as can be seen in Table V.

TABLE V
Returns in lb. m.t. for each added lb. of nitrogen (N) at Swazi and Namireme

	From N40 to N80	From N80 to N120	Mean
Swazi ..	8.38	7.08	7.73
Namireme ..	2.75	1.35	2.05

There are no significant differences due to phosphate or potash applications.

(iii) SULPHATE OF AMMONIA ON LOCAL JAT TEA, THORNWOOD ESTATE (MLANJE)

Superimposed on the three pruning cycles and tipping heights in this experiment are three nitrogen rates. Yields according to nitrogen rates are given in Table VI.

TABLE VI
Yield lb. m.t.p.a. according to nitrogen rate, Thornwood Estate

	40	80	120	L.S.D.
1959/60 season	483	764	1,110	P=0.001=208
Average for 8 seasons	766	1,043	1,348	P=0.001=211

C.V. %, 1959/60, 20.97. C.V. %, 8 seasons, 15.83

During the past season and over the whole eight seasons increasing nitrogen rates have caused highly significant increases in crop.

The returns in tea for each added pound of nitrogen was 7.01 lb. between N40 and N80 and 8.66 between the two higher rates which are in keeping with those from the Swazi N.P.K. experiment. Over the eight seasons the returns average 6.91 and 7.63 lb. respectively.

The exact state of the pruning cycles in any season makes interpretation of response data difficult but crude average returns per added lb. nitrogen over the 8 seasons between the lowest and highest rates are: for the annual cycle 5.82 lb. tea, for the two yearly cycle 7.24 lb. and for the three yearly cycle 8.70. These returns conform with past experience whereby longer cycles make more efficient use of nitrogen applications (*see* Table II above).

(iv) TWO-CUBED N.P.K. EXPERIMENT, LAUDERDALE ESTATE (MLANJE DISTRICT)

This experiment was sited on some of the oldest tea in Nyasaland growing on soils yielding lower potash contents than more recent gardens. During the season it received its third consecutive application of fertilizer treatments which compare in factorial combination nitrogen at the rate of 0 and 80 lb. N. per acre, phosphate at 0 and 60 lb. P_2O_5 per acre and potash at 0 and 60 lb. K_2O per acre. Only nitrogen has caused significant increases in crop and, as reported in previous years by the Senior Agricultural Chemist, it appears that potash reserves, although lower than in the newer tea gardens, are still mobilized readily enough for plant growth.

(v) TWO-CUBED N.P.K. EXPERIMENT, BANDANGA ESTATE (CHOLO DISTRICT)

This experiment similar in treatments to the Lauderdale experiment and deliberately sited on some of the oldest tea in Cholo District, received its fourth annual set of fertilizer treatments. Again significant increases in crop were only caused by sulphate of ammonia.

TABLE VII

The effect of fertilizers on yield in lb. m.t.p.a. at Bandanga Estate, Cholo District

					Nutrient					
					N		P_2O_5		K_2O	
lb. per acre	..	..	..	..	0	80	0	60	0	60
Yield 1959/60	..	..	..	..	232	483	354	361	349	366
L.S.D. $P=0.001=$	..	..	..	..	175		none		none	

C.V. %, 1959/60, 10.24

The return in tea for each added pound of nitrogen was 3.14 which is near to that obtained over the equivalent range from the Namirembe experiment also in Cholo District.

(vi) UREA VERSUS SULPHATE OF AMMONIA—MIMOSA

This new experiment received the first fertilizer treatments during the season. No significant differences were obtained from either sulphate of ammonia or urea dressings. The tea is still immature, being planted in November, 1951, and experience with other experiments on similar aged tea leads to the belief that responses to nitrogen are not high at this stage. Although low nitrogen rates are included in the experiment the tea had been well fertilized before and it is possible that it will take two or three years to overcome residual effects.

(vii) GENERAL

Evidence gained on the past four seasons is indicating that lower responses to nitrogen can be expected in Cholo District. More experiments are now in hand in Cholo but it will be some years before they yield adequate data.

It was possible during the year to begin an examination of past records towards gaining a more detailed insight into the nitrogen utilization picture. Climate and field management method play important parts but the great stumbling block always encountered in analysing accumulated data, is the lack of a satisfactory arithmetical assessment of climate. Without this no real progress has been made. A new approach is being sought and as a start Penman calculations have been made for the past ten years. This has taken up considerable time and no more concrete results can be reported.

During the season chemical analyses were made on the surface soil layer of the Swazi N.P.K. experiment and comparisons with the analyses at the start of the experiment, eight years previously, are detailed by the Senior Agricultural Chemist in his report.

SPACING EXPERIMENTS

(i) INTRODUCTION

In the 1930s a simple spacing experiment was laid down at Swazi. Twenty years later more complex factorial experiments were planted at Mimosa. Yield data from these experiments has been given regularly in past Annual Reports with the results of formal statistical analyses but no rule connecting yield with plant population was apparent until this season. Data collected over the past ten years has now been analysed and collated and it is hoped to publish the detail elsewhere. In this report only the main conclusions are given with a summary of results.

The reciprocal of yield per plant is linearly related to plant population. This is true for Nyasaland, Assam and Indonesian data. Transformation of these linear relationships leads to asymptotic curves which yield no optimum population above which yield decreases (*see* Fig. 2).

A more readily understandable translation and summary of these mathematical functions is contained in Table VIII wherein yields according to varying plant populations are given as percentages of the conventional 4×4 foot square spacing (2,720 plants per acre).

TABLE VIII
Average yields for various ages and plant populations expressed as percentages of 4'×4' spacing (2,720 p.p.a.).

Plants per acre	Nyasaland							Assam	Indonesia
	Age in months after planting								
	18-30	30-42	42-54	54-66	66-78	78-90	Mature		
1,000	65.9	69.9	68.2	69.6	71.2	72.4	69.9	69.4	72.1
2,000	85.9	91.8	91.2	91.7	92.2	92.5	91.7	91.6	92.6
2,720	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3,000	104.1	102.3	102.7	102.4	102.3	102.2	102.4	102.2	102.1
4,000	117.0	108.7	109.5	108.8	108.2	107.6	108.7	108.9	107.8
5,000	126.4	113.0	114.2	113.1	112.1	111.3	112.8	113.1	111.5
6,000	133.5	115.8	117.4	116.1	114.8	113.9	115.9	116.3	114.0
7,000	139.4	118.3	120.0	118.4	116.9	115.8	118.1	118.4	116.0
8,000	143.5	119.7	121.8	120.1	118.5	117.3	119.7	120.3	117.4

After 18-30 months (for Nyasaland) there is a remarkable similarity in proportionate yields between Nyasaland, Assam and Indonesia and because of this it has been possible to calculate one function descriptive of the three countries. The linear form is:

$$\frac{1}{Yp} = 0.001, 242x + 1.07,$$

where Yp is the yield per plant at population x . Transformation of this function leads to the following average percentages applicable to all the three countries.

TABLE IX
Percentage comparisons of yield between 2,720 bushes per acre and other populations calculated from the averages of Nyasaland, Assam and Indonesian functions

Plants per acre					% yield
1,000	..	..	..	..	70.9
2,000	..	..	..	..	92.1
2,720	..	..	..	..	100.0
3,000	..	..	..	..	102.3
4,000	..	..	..	..	108.3
5,000	..	..	..	..	112.4
6,000	..	..	..	..	115.2
7,000	..	..	..	..	117.3
8,000	..	..	..	..	119.0

The yield data were taken from a number of planting patterns and pattern (providing there is a systematic spread over the field) appears not to affect yield response. The choice thus becomes a matter of practical field arrangement. Three of the Nyasaland experiments are shaded with *Grevillea robusta* and two are without shade. *Grevillea* has not affected the proportionate differences. Up to nine years after planting, responses to nitrogen had not interacted with plant population and in lieu of further information the commonly used nitrogen rates can be used without economic loss.

The individual yield curves which are spread over a series of seasons for each age group, include the abnormal drought year of 1957. These curves show that, other than in 1957 and the recovery period thereafter into 1958, the proportionate yield differences according to population vary only little from season to season. In view of this, it appears that although average yields can be expected to be lower in the drier areas of Nyasaland, increases shown in the proportions listed in Tables VIII and IX can nevertheless be expected and that the fear of excessive plant populations are unfounded under normal climatic expectations. Because the yield curves are asymptotic it follows that no theoretical optimum population is apparent and a decision must depend upon field management considerations and the economic implications of Table IX.

Fig. 2 shows average yield curves according to population for various age groups in Nyasaland.

(ii) FOUR SPACINGS AND FOUR SULPHATE OF AMMONIA RATES, MIMOSA

This experiment, badly affected by the 1957 drought, compared in its pre-drought era yields from four plant populations:

4×4 foot square planted	=2,720 plants per acre
4×3 foot rectangular	=3,630 " " "
5×2½×2½ foot double hedge	=4,650 " " "
4×2×2 " " "	=7,260 " " "

Reduced numbers of plants per acre are shown in the column headings of Table X.

Four nitrogen rates, as shown in Table XI are superimposed in factorial combination with the spacing treatments.

For the purposes of record the 1958/59 yields according to plants per acre (post 1957 drought) are given in Table X.

TABLE X
Yield in lb. m.t.p.a. according to four spacing rates

Actual plants in bearing, post 1957 drought	2,285	2,973	3,718	5,682	L.S.D. P=0.05
Yield lb. m.t.p.a.	1,219	1,234	1,272	1,380	106

C.V. %, 1959/60, 9.78

From the formal statistical viewpoint the highest plant population has significantly outyielded the three lower populations, there being no other significant differences. These data fit curves of the type shown in Fig. 2.

There is no significant interaction with nitrogen rates, applied as sulphate of ammonia and average yields according to rate are given in Table XI.

TABLE XI
Yield in lb. m.t.p.a. according to four nitrogen rates

lb. N. p.a.	40	80	160	240	L.S.D.
lb. m.t.p.a.	1,207	1,288	1,325	1,285	P=0.05=106

C.V. % 1958/59, 9.78

There is a significant increase in yield between 40 lb. of nitrogen per acre and 160 lb. A drop in yield occurs between the two highest rates and it is possible that deleterious soil effects are being obtained from the highest application. (The maximum application recommended for commercial use is at present, 120 lb. N. per acre for unpruned tea.)

(iii) COMPLEX EXPERIMENTS, MIMOSA

There are three "Complex" experiments, each planted in successive seasons, and the past season's yields according to plant population (post 1957 drought) are given in Table XII. Original spacing treatments were 4×4 foot square (2,720 p.p.a.), 4×3 foot rectangular (3,630 p.p.a.) and 4×2×2 foot double hedge (7,260 p.p.a.).

TABLE XII
Yield in lb. m.t.p.a. from three Complex Experiments according to age and spacing

Experiment	Age at end of season	Plants in bearing p.a.	Yield lb. m.t. p.a.	L.S.D.		C.V. %
				0.05	0.01	
I	7.5 yrs.	1,930 2,480 4,520	783 825 968	93	126	15.29
II	6.5 yrs.	2,210 2,870 5,110	1,054 1,179 1,293	66	88	10.19
III	5.5 yrs.	2,300 2,800 4,430	823 879 980	47	63	9.50

Formal significant increases in yield are due to increasing plant populations in each experiment. The data fit yield curves of the type shown in Fig. 2.

Nitrogen in the form of sulphate of ammonia, was applied to these three experiments, in factorial combination, at the rates of 40, 80 or 120 lb. N. per acre but there were no significant differences caused by these treatments. There was no significant interaction between nitrogen rates and spacing.

Permanent Shading of Tea

(i) SHADE TREES AND N.P.K. MIMOSA

In this experiment in the Mlanje District, the effects of three permanent shade trees are compared with unshaded tea and superimposed under the shade treatments are four nitrogen rates with and without phosphate or potash applications. At the end of the season the tea was 8.5 years old from transplanting in the field and the shade trees one year younger. All shade species have developed canopies near to those offered by mature trees.

Yields according to shade treatments for the present and past seasons are given in Table XIII.

TABLE XIII

Yields in lb. m.t.p.a. according to shade treatment and age from planting

Season	Age, yrs at end of Season	Shade species and spacing				L.S.D.	
		<i>Glyricidia maculata</i>	<i>Albizzia gummifera</i>	<i>Grevillea robusta</i>	No shade		
		28 feet Square	40 feet Square	40 feet Square	—	0.05	0.01
1953/54	2.5	96	110	112	90	—	—
1954/55	3.5	198	233	235	215	—	—
1955/56	4.5	545	665	662	610	48	75
1956/57	5.5	821	898	968	947	48	75
1957/58	6.5	472	578	736	756	157	246
1958/59	7.5	1,040	1,093	1,432	1,551	248	390
1959/60	8.5	951	874	1,397	1,479	318	498

During the past season *Albizzia* and *Glyricidia* have significantly reduced crop in comparison with *Grevillea* shade and no shade. There are no significant differences within these pairs of treatments.

As the seasons have progressed the depressing effects on yield of *Albizzia* and *Glyricidia* become more pronounced. It is apparent from discussions with workers in East Africa that the facilities at these stations are not adequate to enable a detailed investigation into the shade problem to be undertaken and thus the results in Table XIII are offered at their face value without explanation. The design of a satisfying shade experiment is very difficult and this experiment will not enable shelter effects to be separated from shade effects. The unshaded plots are sheltered by the shaded plots.

An attempt is being made elsewhere on the station to assess the effects of shelter on yield by the use of non-living shelter barriers but first results will not be available until the end of next season at the earliest.

There have been no significant differences caused by fertilizers considered as main treatments. The phosphate application (30 lb. P_2O_5 p.a.) under *Grevillea* has just,

and only just, caused a significant reduction in yield in comparison with no phosphate yields under *Grevillea*. Fallen leaves are not removed from the plots and in view of East African experiments a close watch will be kept on this possible interaction. This year's result is doubtful as it is only just significant by one pound of tea at $P=0.05$ and only so for the first time.

(ii) OBSERVATION PLOTS, SWAZI

Recordings continue to be made under non-replicated plots of mature tea with and without mature *Albizzia gummifera* or young *Grevillea robusta* shade trees. Plots are split so that half of each receives no fertilizer and the remainder the equivalent of 80 lb. N. per acre applied as sulphate of ammonia. The tea was in its second year from prune.

Yields for the past season are given in Tables XIV and XV.

TABLE XIV
Yields in lb. m.t.p.a. under *Albizzia gummifera* shade

				<i>Albizzia</i>		Mean for nitrogen
				Without	With	
Without nitrogen	..	..	..	389	700	545
With 80 lb. N. p.a.	..	..	..	789	841	815
Mean for shade	..	..	..	589	770	—

The overall effect of *Albizzia* has been to increase yield. Yields shown in Table XIII are taken from immature tea in contrast with the tea in these observation plots, which is approaching 30 years of age. It is possible therefore that age of tea has a part to play in the shade story and on more than one occasion caution has been suggested when considering the wholesale removal of shade trees from young tea.

The increase due to *Albizzia* is 77 per cent. of that caused by 80 lb. of nitrogen added to the unshaded plots. Shade, as in past seasons, has had a depressing effect upon nitrogen efficiency; under no shade each pound of added nitrogen returned 5.00 lb. of tea but under shade the return was only 1.76 lb.

In past reports it has been noted that the intensity of the shade effect appeared to coincide positively with the age from prune; the longer from prune the greater the effect. In 1958 the tea was pruned and shade if anything, had a slightly depressing effect during the 1958/59 season. This season shade effects are positive and pronounced and the tea is unpruned. Support is thus added to the previously suggested pattern of response according to age from prune.

TABLE XV
Yields in lb. m.t.p.a. under *Grevillea robusta*

				<i>Grevillea</i>		Mean for nitrogen
				Without	With	
Without nitrogen	..	..	..	405	495	450
With 80 lb. N. p.a.	..	..	..	1,029	996	1,012
Mean for shade	..	..	..	717	745	—

There is little difference in mean yields due to shade effects. *Grevillea* has had a slightly depressing effect on the returns from the nitrogen application, it being 6.26 lb. of tea returned under shade for every pound of added nitrogen against 7.80 from the no shade plots.

The tea is the same age as that under the *Albizzia* shade but the *Grevillea* trees were only planted in 1955. They are suffering severely from competition with the surrounding mature tea and do not yet offer an adult shade canopy.

Arboricides

The objections to ring-barking as a control for *Armillaria mellea* are twofold. Firstly it requires at least two years before all the common tree species are dead under Nyasaland conditions and secondly regeneration of bark across the ring means that continual watch must be kept from start to finish of the operation. An investigation was therefore started to examine the possibilities of using arboricides to shorten the time span and work involved, by conventional ring-barking. (A warning must be interpolated here, that results are not completed and ring-barking is the only method of *Armillaria* control that can at present be offered with confidence.) Although the trial was originally intended for forest species prior to clearing, a further urgency was added when *Armillaria* outbreaks followed conventional ring-barking of mature *Grevilleas* in mature tea during a shade thinning programme on one estate.

In September, 1959, 20 cc. per inch of girth of solutions of the arboricides listed below were applied in frills cut into the bark of seven indigenous tree species and four trees of each received each treatment. Treatments and species used were:

Treatments

1. Untreated.
2. Conventional ring-barking.
3. 2.4-D, 5 per cent. solution in diesel oil.
4. 2.4.5-T, 5 per cent. solution in diesel oil.

<i>Species</i>	<i>Local Name</i>
1. <i>Uapaca kirkiana</i>	<i>Msuku</i>
2. <i>Cussonia kirkii</i>	<i>Mbwabwa</i>
3. <i>Brachystegia</i> sp.	<i>Kaphone</i>
4. <i>Afromosia angolensis</i>	<i>Muwanga</i>
5. <i>Parinari mobola</i>	<i>Muula</i>
6. <i>Erythrina abyssinica</i>	<i>Chizungwa</i>
7. <i>Pterocarpus angolensis</i>	<i>Mlombwa</i>

Two months after chemical treatment some species showed a marked reaction, mainly in the form of cracks in the bark spreading upwards and downwards from the frill.

Table XVI records in summary form results at September, 1960, twelve months after treatments were first applied.

TABLE XVI

The effect of ring-barking and two arboricides on indigenous tree species

Species	Control	Ring-bark	2.4-D	2.4.5-T
<i>U. kirkiana</i>	Normal growth	Foliage yellowing on two trees. No deaths.	Bark cracks on all trees. One tree dead and two with yellow leaves.	Bark cracks on all trees. Three dead, fourth yellow foliage.
<i>C. kirkii</i>	Normal growth	Three dead, fourth yellow foliage.	All dead.	All dead.
<i>Brachystegia</i>	Normal growth	Foliage yellowing on two trees.	Gum exudation and distorted foliage.	Distorted foliage. One dead.
<i>A. angolensis</i>	Normal growth	Apparently normal growth but leaf yellowing on one tree.	Two dead, two apparently normal growth.	Confusing. Two possibly dead. One yellow foliage and one shooting from base of tree.
<i>P. mobola</i>	Normal growth	Full foliage in canopy and new shoots below ring.	Aerial parts dead but some shoots below frill.	All dead with 1 tree having 1 basal shoot
<i>E. abyssinica</i>	Normal growth	Two dead, third defoliating, fourth yellow foliage.	Two dead and remainder almost defoliated.	Three dead, fourth defoliated.
<i>P. angolensis</i>	Normal growth	All dead.	All dead.	Two dead, one dying. One vacancy.

Only the most tentative conclusions are made at present. The rate of kill depended upon treatment and species, some being less resistant than others. 2.4.5-T was more toxic than 2.4-D. Chemical analyses on roots have been made for carbohydrate content and the present indications are that arboricides do reduce starch. Details are given in the Senior Agricultural Chemist's report.

Ultimately, attempts will be made to culture *Armillaria* on dead root sections.

At the end of January one extra tree of each species was treated with 2.4.5-T and compared with single trees inoculated with a 2 per cent. aqueous solution of T.B.A. Seven months later three of 2.4.5-T treated species were dead but T.B.A. had had no visible effect.

In August, 1960, arboricides were applied to *Grevillea robusta* shade trees growing in tea at Mimosa but no detailed results are ready for report. Early above-ground indications are that *Grevillea* is very susceptible to arboricides and abnormal symptoms were noticed in some plots one month after treatments were first applied.

Agronomy General

Besides the results given so far in this report the Agronomy Section has been involved in a series of new experiments. These, most of which are under uniformity recording or under treatment for the first time, include:

- (1) Irrigation with fertilizer studies on mature tea at Cholo and Mlanje.
- (2) Shelter belt observation at Mlanje.

- (3) Time of pruning, nitrogen rates and length of pruning cycle in Cholo.
- (4) Two experiments are in the nursery stages at Cholo and Mlanje, and will compare methods of transplanting to the field six month old seedlings in polythene pots.
- (5) Water penetration rates on Cholo and Mlanje soils for conservation and irrigation purposes.
- (6) Land and nursery preparations for the first field experiments to be planted at the Cholo station and extensions at Mimosa. With the 1960/61 planting rains some 21 new experiments and observations, of major or minor size, will be planted.

A start has been made on Penman calculations and Mlanje meteorological data has been so co-ordinated from January, 1949, to date.

Plant Improvement

This section of the station's work received encouragement and impetus half way through the season by the appointment of a Plant Breeder in charge. Together with the Horticulturist the team is responsible for pursuing all methods which might lead to an improvement in the types of tea that will be planted, either as vegetatively propagated clones or by seed from improved sources.

Plant Breeder's Report

CONTROLLED POLLINATION

Techniques were developed for controlled pollination of tea flowers. 91 cross pollinations were made between six-year-old Betjan seed bearers and, at three months, 63 appear to have been successful with seed beginning to be set. No cases of incompatibility were met.

The female parts of tea flowers normally receive pollen brought by insects from the flowers of other tea bushes as well as from flowers on its own bush and from its own stamens. Physiological factors exist however which ensure that fertilization is effected by pollen from a different bush rather than by self pollen. This results in the viability and vigour of the species which is an advantage in the struggle for existence in natural conditions.

If pollen from other bushes is excluded a limited degree of self fertilization does occur. Seeds resulting, however, are likely to be of poor germination capacity and to give weakly plants but ones which would show trueness to the type of the mother bush. This represents the most extreme form of line breeding and a potentially important plant breeding method. Much attention was thus given to self pollinations.

Bushes worked on were six-year-old Betjan seed bearers in isolation area No. 5 at Mimosa and by kind permission of Mr. J. F. Ramsden, of Lujeri Estates, certain elite bushes in his Tingamira seed garden. The dropping off of the corolla (petals) and the closing of the calyx (sepals) over the ovary after pollination are regarded as signs that fertilization has taken place. Many instances occur however in which young fruits are shed before they come to maturity. This is especially so with self pollination. The figures given below are therefore interim ones only and the proportions of eventual successes may be much smaller. The hormone alpha naphthalene-acetic acid (40 p.p.m.) was sprayed on to the flowers at the time of selfing as there were indications that this might aid fertilization. The first results of this were good and at one month after pollination its use had apparently doubled the number of successful selfs. At three months however the proportion of young fruits remaining has dropped to almost exactly the same as that of the untreated controls.

TABLE XVII

Source					No. of self pollina- tions	No. of fruits set at 3 months	Per- centage set
Betjan ..	..	..	..	..	855	211	24.7
Tingamira ..	..	..	..	..	316	93	29.4
With N.A.A. ..	..	..	..	..	50	7	14.0
Without N.A.A. ..	..	..	..	..	50	9	18.0

There is a great difference between trees in the proportion of successful selfs to date; on some trees 75 per cent. of flowers pollinated are bearing young fruits, on others there are none.

SEED INTRODUCTIONS

By the kind co-operation of the Departments of Agriculture of Uganda and Nyasaland small quantities of seed were received from Uganda. About 300 seedlings of Kalline, Dahootia and Rajghur and 1,200 seedlings of Betjan have been established. The latter are divided into the progeny of 20 separate trees.

About 6 lb. seed provided by Nyasa Tea Estates and Lujeri Estates was exchanged for similar quantities of polyclonal and selected seed from the Research Station of Tshibinda-Mulungu, Belgian Congo.

METHODS OF INDUCING EARLY FLOWERING

In order to speed up the turn-over of generations and thus accelerate up the progress of the plant breeding programme, methods of inducing early flowering are being investigated.

At Mimosa a nursery of about 1,000 plants of Betjan, Tingamira and Rajghur has been established by transplantation. These comprise seedlings planted in 1958, 1959 and 1960. From the beginning of June, 1960, the nursery has been illuminated every evening from dusk until 10 p.m. The lighting consists of 11 ordinary 100 watt tungsten filament lamps to a nursery area of about 500 square feet. It is hoped that this will have the same effect as increasing the day length and thus induce early flowering.

Two substances, Gibberellin and N.A.A. (alpha naphthalene-acetic acid) which are known to affect plant growth and in certain circumstances flower production, have been periodically sprayed on selected plants. N.A.A. had a depressing effect on the growth of the seedlings and no definite effect has yet been seen from the Gibberellin.

FIELD TRIALS

The following field trials have been planned in conjunction with the Plant Improvement programme:

(a) *The Juvenile Vigour Trial.* The object of this trial is to determine those measurable characters of juvenile tea plants which are expressions of vigour and which are correlated with vigour and high yield of the bushes when mature.

(b) *Estates Variety Trial.* This trial will test and compare the yield and quality of tea derived from the seed gardens of 26 estates in Mlanje, Cholo and Rhodesia.

(c) *Trial of Juvenile Characteristics of Individual Bushes.* This trial will attempt to find out if there is any relationship between such characters of seedlings as leaf shape, colour, size etc. and the yield and quality of the bush when mature.

A great many measurements in connection with trials (a) and (c) have already been made in the nurseries. It is proposed to plant the trials in the fields at Mimosa and Cholo at the onset of the 1960/61 rains.

MINIATURE MANUFACTURE

A Pizey miniature roller, a miniature C.T.C. machine and a drying oven have been installed and are now in working order at Mimosa. Several batches of tea have been successfully manufactured. This facility will be of great use in the future in connection with all aspects of the research work.

CLONAL SEED GARDEN

Preparations have been made for the establishing of a clonal seed garden at Mimosa. This is to be regarded as strictly experimental and to gain experience in the establishment and management of such a garden.

Five bushes of Betjan in isolation area No. 5 at Mimosa originally selected as good and bright fermenters by the chloroform test, were manufactured individually. All confirmed the evidence of the chloroform test in that they produced tea which gave a very bright infusion and liquor. Cuttings have been taken from these bushes and are being propagated in the mist propagation unit at Swazi. It is anticipated that by December, plants from them will be available for planting out in an area of approximately 2 acres which has been prepared and can be irrigated.

FERMENTATION INVESTIGATION

Various work has been done by the Section in conjunction with the biochemical investigation into tea fermentation. From March to June weekly samples of shoots from selected good and bad fermenting bushes were sent by air to Cambridge. It has been suggested that the environment of Nyasaland may have some effect on the fermentation of tea grown here. In order to test this, unrooted cuttings from two good and two bad fermenting clones were sent to the Tea Research Institute of East Africa, and the Tea Research Institute of Ceylon. The Directors of these two institutes have kindly agreed to grow plants from these cuttings and to report on their fermentation ability under their respective conditions. This should provide most useful and critical information.

FIELD SELECTIONS

In March, 1959, a 1.4 acre field of Indian hybrid tea spaced at 4' x 4' triangular, at Swazi was pruned. In the field the first 112 bushes to break away from prune were marked and their subsequent yields recorded individually over 11 plucking rounds until February, 1960. Fermentation tests were made on two or more occasions and later the area of each bush was measured.

Total yields for the 11 plucking rounds were found to vary from 1,924 gm. to 181 gm. whilst bush area varied from 26 square feet to 3.25 square feet. Over the whole range a statistically highly significant positive correlation was shown to exist between yield and bush area. Individual bushes, however, did vary from the average yield to area ratio. One bush which had the highest total yield, equivalent to 2,200 lb. of made tea per acre, also had the highest yield to area ratio. It was also a very good bright fermenter and is thus potentially valuable. A clone has been established from it.

All the recorded bushes were allowed to grow up unplucked as from February, 1960, in order that cuttings could be taken from them. Cuttings were taken and are being propagated from 20 bushes representing points all along the range of total yield. The behaviour of the resultant clones will be of great interest when related to characteristics of the parent bushes.

Another series of selections has been made from fields at Swazi which were pruned in March, 1960. Factors governing selection were, speed of break away from prune, bush area, fermentation ability and leaf type.

Horticulturist's Report

INTRODUCTION

The problem of vegetative propagation of tea by cuttings or layers may be divided into two halves:

- (a) the production of roots (striking) and,
- (b) the establishment of the new plant in the field.

Work on the production of roots has been in progress for some time but this is the first year it has been possible to give attention to establishment in the field and first results are far from being satisfactory. Much work will be required in the future on this aspect of vegetative propagation.

The year's work on rooting cuttings has been mainly devoted to an investigation into the effect of shade. Other investigations included the influences on striking of growth cycle, terminal bud state and growth substances. The completion and use of the mist propagation unit has been a great advance, and has proved its worth, even though it is not likely to be used on the large scale commercial production of cuttings.

It was not possible to develop work on root cuttings or air layers and although a few bud grafts were made on the Cholo Highlands Group of Estates and some stem grafts at the Swazi Station none was successful.

Considerable time was spent on fermentation testing and in setting up the miniature manufacturing machinery.

TIME OF TAKING CUTTINGS IN RELATIONSHIP TO THE GROWTH CYCLE

The growth cycle/survival observations recorded in earlier annual reports were continued, and throughout the year 20 cuttings from each 3 clones were planted at weekly intervals.

Fig. 3 shows the percentage of growing buds on undisturbed material at the time cuttings were taken and the percentage of those cuttings surviving 4 months later. (Earlier work has related survival at four months to rooting.)

For the third year in succession there is an indication that survival is higher with cuttings taken from mother bushes in a predominantly dormant state, although it is less marked in clone B16 this year than in previous years. It seems likely that the growth cycle has a very definite effect on the rooting of cuttings, and that under local conditions, the break away from a dormant period is the best time for taking cuttings.

This experiment has now been discontinued.

INDIVIDUAL TERMINAL BUD INFLUENCE ON THE ROOTING OF CUTTINGS

The indication from last year's work that the growth cycle affects the rooting of cuttings on average, has been followed up by a preliminary investigation into the influence of the individual terminal bud state on cuttings made from the stem beneath it.

Other workers have suggested that the removal of the terminal bud before cuttings are made increases rooting, so this treatment was included.

Thirty-one selected bushes at Mimosa were allowed to grow unplucked from November until April, when two weeks prior to propagation one third of the shoots from each bush were tipped by removing the apical bud and first two leaves. Some of these buds were growing and others were dormant.

In May the entire crop of shoots was removed and divided into three groups of:

- (a) apical bud growing
- (b) apical bud dormant
- (c) apical bud previously removed.

For each experiment single node cuttings were made from each group and planted under a double layer of woven bamboo laths, which was reduced to a single layer two weeks later. The surviving cuttings were transplanted to the conventional high nursery shade during January, 1960, and it is hoped to use them as stumps during the 1961/62 rains. Table XVIII shows the percentages of cuttings transplanted and surviving at 14 months.

TABLE XVIII
Terminal bud influence on the survival of cuttings

Bud state at time of taking cuttings	<i>Dormant</i>	<i>Growing</i>	<i>Bud previously removed</i>
% Transplanted	38.4	44.0	40.0
% Surviving at 14 months ..	32.1	37.0	33.6

The data in Table XVIII indicate that there was little influence on rooting caused by the apical bud and there seems to be little benefit from removing the apical bud two weeks prior to making cuttings. Consideration of the growth-cycle results, and the axillary bud state observations, summarized in the report for 1958/59, tends to add weight to the conclusion that the bud state of the *individual* shoot from which these cuttings were taken, had little influence on rooting, but paradoxically the growth cycle of the parent bush as a whole exerted a strong influence on average results. More detailed research is obviously needed to clarify this apparent confusion.

In this experiment the overall percentage of rooting was low, due partly to the fact that of the 31 selected bushes only 12 could be considered as good rooters. Rooting ability is considered to be an important point in selecting material for large scale propagation.

FACTORIAL EXPERIMENT UTILIZING SHADES, CLONES AND GROWING SUBSTANCE

In May, 1959, a factorial experiment was planted using single node green and red barked cuttings, and compared the following treatments:

Shade: Plots were surrounded by honeycomb brick walls and shaded by frames covered in the following manner:

a0=one layer of grey sheeting=approx. 50 per cent. outside light penetration.

a1=two layers of grey sheeting=approx. 25 per cent. outside light penetration.

a2=three layers of grey sheeting=approx. 12.5 per cent. outside light penetration.

The light intensity measurements were made on reflected light using a Weston Exposure meter and are compared with full outside light.

Growth Substance: Cuttings were treated by a three second dip of their basal ends in a naphthalene-acetic acid N.A.A. in aqueous solution.

b0=water alone as control.

b1=3,200 parts per million N.A.A.

b2=32,000 parts per million N.A.A.

Clones: To investigate the possibility of different clones requiring different conditions three clones were used, selected purely on the basis of there being adequate material available.

c0=SW1

c1=SW6

c2=B10

The design was a three-cubed factorial, partially confounded, with two complete replications divided into 6 blocks each of 9 plots, each plot containing 50 cuttings.

Watering was usually twice or thrice per week being sufficient to keep the medium moist and uniform over all treatments. Frequent recordings were made of survival percentages and results at 30 weeks are given in Table XIX. The analysis being carried out on angular transformations of the crude data and significant differences are based on the transformed data.

TABLE XIX
The percentage survival of cuttings at 30 weeks

<i>Treatment</i>	% <i>Full light</i>			<i>N.A.A. in p.p.m.</i>			<i>Clone</i>		
<i>Rate</i>	50	25	12.5	<i>None</i>	3,200	32,000	SW1	SW6	B10
Percentage survival (crude data) ..	55.3	71.1	72.2	62.3	70.4	65.9	64.0	70.8	63.9

C.V. % (Angular transformation), 18.0

The shade yielded by the two or three layers of cloth had a significantly better effect than the single cloth ($P=0.01$). There was no significant difference between two and three cloths. There were no significant differences caused by growth substance or by clonal treatments.

At 34 weeks after planting, random samples of 5 cuttings per plot were taken and the following measurements and counts made:

- (a) number of roots
- (b) total length of roots
- (c) number of shoots
- (d) total length of shoots.

Tables XX to XXIII present these data expressed as average per cutting and these averages include nil values where deaths had occurred.

TABLE XX
The average number of roots per cutting

<i>Treatment</i>	% <i>Full light</i>			<i>N.A.A. in p.p.m.</i>			<i>Clone</i>			<i>L.S.D.</i>	
<i>Rate</i> ..	50	25	12.5	0	3,200	32,000	SW1	SW6	B10	0.05	0.01
Root Numbers	18.2	22.3	21.0	17.4	20.4	23.6	20.5	16.8	24.2	5.6	7.6

C.V. %, 39

The average numbers of roots per cutting were not affected significantly by clonal or shade differences. The strongest concentration of growth substance (32,000 p.p.m.) caused significantly more roots than no growth substance. There was an indication of an interaction between shade and growth substance. The two cloth shade being more effective with the weaker strength of growth substance. Table XXI gives the average total length of roots per cutting.

TABLE XXI

The average length of roots per cutting in centimetres

Treatment	% Full light			N.A.A. in p.p.m.			Clone			L.S.D.	
	50	25	12.5	0	3,200	32,000	SW1	SW6	B10	0.05	0.01
Rate ..											
Root Length ..	109.5	148.4	142.0	115.3	133.3	151.2	97.9	133.7	168.3	23.9	34.2

C.V.%, 26

All main treatments caused significant differences in the length of roots produced. The two heavier shades, although not differing between themselves, significantly increased total root length. The strongest concentration of growth substance caused a significant increase in root length compared with the untreated control.

TABLE XXII

The average number of shoots per cutting

Treatment	% Full light			N.A.A. in p.p.m.			Clone			L.S.D.	
	50	25	12.5	0	3,200	32,000	SW1	SW6	B10	0.05	0.01
Rate ..											
Shoot Number	0.60	0.67	0.66	0.64	0.68	0.60	0.62	0.64	0.66	0.12	0.21

C.V.%, 36

Treatments caused no significant differences to the number of shoots produced from the cuttings.

TABLE XXIII

The average length of shoots per cutting in centimetres

Treatment	% Full light			N.A.A. in p.p.m.			Clone			L.S.D.	
	50	25	12.5	0	3,200	32,000	SW1	SW6	B10	0.05	0.01
Rate ..											
Shoot Length ..	13.3	13.5	12.1	12.1	13.1	13.7	7.3	14.3	17.3	4.1	5.6

C.V.%, 46

The only significant differences between shoot lengths were caused by clones.

Summary of these results:

(i) *Shade*: The single cloth shade reduced survival and root growth, and it would seem that 25 per cent. of full light (two cloths) was preferable under the conditions of this experiment.

(ii) *Growth Substance*: Naphthalene-acetic acid at the rate of 32,000 parts per million in aqueous solution, had no significant effect on survival but caused a significant increase in average root number and length per cuttings. Whether these factors will ultimately be beneficial in final establishment in the field remains to be seen.

(iii) *Clones*: As may be expected there were differences in responses between clones, but there were no clearly significant interactions with other treatments which indicates that the different clones used in the experiment would not require individual attention were they used on a commercial scale.

In the 1958/59 report a similar experiment to the one above was described, and it is of interest to compare the results. The 1958/59 experiment was in two halves, green barked and red barked cuttings, but in the 1959/60 experiment the different cuttings were mixed. The figures in table have been adjusted to assume the same proportions of red and green barked cuttings in both years. No major differences in trend are apparent.

TABLE XXIV
The percentage survival of cuttings at 30 weeks

<i>Season</i>	<i>Clones</i>			<i>Shade range as % of full light</i>			
	<i>SW1</i>	<i>SW6</i>	<i>B10</i>	<i>50</i>	<i>25</i>	<i>12.5</i>	<i>6.25</i>
1958/59	64.1	63.4	70.6	—	60.3	67.0	70.8
1959/60	62.3	70.4	65.9	55.3	71.1	72.2	—

C.V. % (for angular transformation) .. 1958/59, 12
1959/60, 18

SHADE EXPERIMENTS

Early in the vegetative propagation investigations, the important effect of shade intensity on survival was noticed. In pursuance of this facet, two experiments involving six shade treatments were undertaken.

In these, the shade was woven bamboo laths supported on honeycomb brick walls, the rooting medium was ordinary nursery soil and watering was twice or thrice weekly, sufficient to keep the soil moist. Single node cuttings, a mixture of red and green barked material, were planted in May, 1959. One experiment was at Mlanje and the other at Cholo. In both 3 clones were used, one being common to both experiments.

The shade treatments were manipulated at six weekly periods as indicated in Table XXV.

TABLE XXV
Shade treatments in layers of bamboo laths according to the time from planting the cuttings

<i>Treatment</i>					<i>1st six weeks</i>	<i>2nd six weeks</i>	<i>After 12 weeks</i>	<i>Code</i>
1	..	..	..	..	3 layers	3 layers	3 layers	3+3+3
2	..	..	..	..	3 "	2 "	2 "	3+2+2
3	..	..	..	..	3 "	2 "	1 "	3+2+1
4	..	..	..	..	2 "	2 "	2 "	2+2+2
5	..	..	..	..	2 "	1 "	1 "	2+1+1
6	..	..	..	..	1 "	1 "	1 "	1+1+1

An assessment of light intensity was made using a Weston light meter, and readings were:

Under 3 laths= 0.6 per cent. of full light.
 „ 2 laths= 2.3 per cent. of full light.
 „ 1 lath =16.0 per cent. of full light.

Survival counts were made at regular intervals and the data recorded below are for survival at 30 weeks after planting. Table XXVI gives Mlanje data and Table XXVII those for Cholo. The crude recordings showed a distinct skewness and analyses were therefore calculated on transformed data; the transformation constant being $p=\sin^2x$. In the discussion, significant differences refer to the analyses on the transformed data.

TABLE XXVI

The percentage survival of cuttings under differing shades at Mlanje

Clone			Shade Regime, Coded:						Mean for clones
			2+2+2	3+2+2	2+1+1	3+2+1	1+1+1	3+3+3	
SW7	..	..	74.4	81.0	88.8	78.8	81.0	47.8	75.4
B9	..	..	77.8	69.9	72.2	64.4	64.4	57.8	67.8
B6	..	..	78.8	74.4	62.2	70.0	54.4	61.1	67.0
Mean for shades	..	..	77.0	75.2	74.4	71.5	66.7	55.6	—

C.V. % (Transformed data) Shades, 6.2; Clones, 3.2

Considering shade treatments; 2+2+2, 3+2+2 and 2+1+1 are significantly better than 3+3+3 ($P=0.05$). This is a result in favour of medium shade. Under the lightest shade treatment, deaths in the early weeks were high, but not significantly so. Clonal differences are not significant.

TABLE XXVII

The percentage survival of cuttings under differing shades at Cholo

Clone			Shade Regime, Coded:						Mean for clones
			2+1+1	1+1+1	2+2+2	3+2+2	3+2+1	3+3+3	
L7	..	..	64.4	61.0	43.3	48.9	50.0	32.2	50.0
SW7	..	..	72.2	52.2	43.3	41.1	41.1	14.4	44.1
B14	..	..	46.7	54.4	53.3	24.4	21.1	22.2	37.0
Mean for shade	..	..	61.1	55.9	46.7	38.1	37.4	23.0	—

C.V. % (Transformed data) Shades, 10.6; Clones, 6.2

There is a significant indication that 3 laths in the early or late stages were detrimental in the Cholo experiment ($P=0.05$) and the results again favour a medium to light lath shade. Differences between clones were not significant.

A comparison of shade effects between Mlanje and Cholo leads to the tentative conclusion that less shade is required in Cholo than Mlanje. This is probably due to temperature differences between the two Stations. The stations are about 40 miles apart and on approximately the same latitude but Cholo is at an altitude of about 3,000 feet above sea level and Swazi at 2,060 feet. At Cholo under cooler conditions, cuttings react more strongly against heavy shade and respond better to lighter shade, whereas at Mlanje, cuttings react against the two extremes of 3+3+3 and 1+1+1; perhaps indicating detrimental effects of excess temperatures under the latter.

One of the clones used in each experiment was common to both and Table XXVIII gives the survival percentage at 30 weeks for this clone on the two stations:

TABLE XXVIII

The percentage survival of clone SW7 under different shades at Mlanje and Cholo

Station			Shade regime, Coded:						Mean for station
			2 + 1 + 1	1 + 1 + 1	3 + 2 + 2	3 + 2 + 1	2 + 2 + 2	3 + 3 + 3	
Mlanje	..	..	88.8	81.0	81.0	78.8	74.4	47.8	75.4
Cholo	..	..	72.2	52.2	41.1	41.1	43.3	14.4	44.1
Shade mean	..	..	80.5	66.6	61.1	59.9	58.8	31.6	—

It is interesting to note that the order of merit of the response to shade treatment by this clone is very similar.

The practical advice, at present, resulting from these experiments is that for both districts a 2 lath shade should be used for the first six weeks and then reduced to a single lath thereafter. The slight indications obtained that different clones may need different shade conditions are as yet considered to be of doubtful practical importance but it is a matter that is being borne in mind.

The overall percentage of survival is lower at Cholo than it is at Mlanje. This may be due to a number of factors:

(a) Climatic differences

(b) Soil differences

(c) At Cholo the laths were attacked by borers and deposits of frass may have affected the cuttings.

These factors are under observation in the 1960/61 experiments, and meteorological instruments are now installed at Cholo.

Establishment of Rooted Cuttings in the Field

(i) ESTABLISHMENT AT APPROXIMATELY SIX MONTHS OLD

Cuttings planted in April, 1958, were transplanted to the field at Mimosa and Cholo during the following 1958/59 rains. At Mimosa transplanting was done in December, 1958, but was unfortunately soon followed by adverse weather and survival was very poor. Irrigation facilities were not available. At Cholo the cuttings were not transplanted until March, 1959; because of the earlier experience at Mimosa they were shaded and watered. Survival was practically complete. Survival percentages are given in Table XXIX.

TABLE XXIX

Survival of transplanted cuttings

Station			Mlanje			Cholo		
Clone			SW1	SW6	B10	SW1	SW6	B10
Cuttings planted	..	..	103	111	111	35	56	50
% Survival June 1960	..	..	1	25	9	83	100	98

(ii) ESTABLISHMENT USING CUTTINGS WITH LEAVES ATTACHED IN POLYTHENE TUBES

A series of observation trials has been made in establishing cuttings in polythene tubes and thereafter transplanting them to the field. Whilst cuttings can be well grown in tubes, success in transplanting in the field thereafter has been disappointingly poor and much remains to be done in developing transplanting methods. Experience to date shows that transplanted cuttings in leaf lack resistance to even moderately adverse weather conditions in the months following transplanting.

(iii) ESTABLISHMENT USING 30-MONTH-OLD STUMPED-CUTTINGS

The conventional method of establishing seedling tea in Nyasaland is by stump planting. That is, thirty-month-old seedlings are pruned at four inches above nursery bed level, uprooted and the plant, without leaf and with a bare root, is transplanted into the field. This method of establishment has proved satisfactory under even the most adverse climatic conditions.

An observation was made using a very few stumped thirty-month-old cuttings. Transplanting took place in March, 1960, and at the time of writing survival is practically complete. This method appears promising. A large stump planting programme is scheduled for the oncoming rains.

Stumped cuttings after establishment show sulphur deficiency symptoms more readily than seedlings of equivalent age and this is perhaps an expression of a less vigorous rooting system. Ammonium sulphate applications very shortly after planting appear absolutely essential.

(iv) ROOTING HABIT

Opportunity was taken to examine rooting patterns at uprooting time and three characteristic systems were found and are influenced by clone:

- (a) a horizontal surface spreading system
- (b) an inverted cone of 4 to 5 thick woody roots spreading at an angle of 45 degrees to the surface soil
- (c) a pattern more typical of seedlings with some roots penetrating vertically downwards.

General

Until this season, development has been largely connected with methods of striking cuttings and with the growth in the nursery thereafter. Success has been steady over the past four years and the expectation of survival through to the nursery stage has been nearly tripled.

At the start of the 1960/61 rains the first reasonably sized quantities of thirty-month-old cuttings will become available in the nurseries and from then onwards it will be possible to extend the programme into establishment methods in the field.

In common with the plant improvement programme, all cuttings produced before and during the final nursery stages are now being recorded for various juvenile characteristics in the hope that ultimately an examination of these will show correlations with mature behaviour thereby enabling time to be saved by eliminating potentially poor survivors at an early stage.

The main season for taking cuttings overlaps June, the end of the formal crop season. The following experiments and observations were planted during 1960 but will not be ready for report until next year.

(i) An investigation into watering frequency and quantity under various shade treatments.

(ii) A repeat of the lath density shade experiment.

(iii) A trial comparing two Mlanje and two Cholo soils as rooting media.

The above are repeated at Mlanje and Cholo.

(iv) An observation trial on the check to growth in the nursery caused by transplanting six-month-old cuttings from striking beds in comparison with cuttings struck and left *in situ*.

(v) The effect of Gibberellic acid on the rooting of cuttings from 3 clones.

(vi) The effect of 4 growth substances on rooting of cuttings from 3 clones.

(vii) Fertilizer trials on cuttings under mist propagation.

(viii) The establishment of cuttings rooted under mist.

(ix) The rooting of cuttings under polythene tents.

MIST PROPAGATION

The value of continuous or intermittent mist units has been frequently demonstrated for the establishment of cuttings from species not responsive to more simple methods. In the plant breeding programme it might become essential to establish vegetatively a few plants containing valuable characteristics and if this cannot be achieved by simple methods the use of mist would be economically worthwhile.

Preliminary investigations into the design and use of a mist propagation unit suitable for our purposes was begun in 1956 but because of the lack of mains electricity and a mains water supply, difficulties were encountered and it was not until 1959 that equipment was finally in use.

EVALUATION OF THE MIST UNIT

During September, 1959, single node cuttings of two clones were planted in various media under both continuous and intermittent mist in the glass house. At the same time similar cuttings were planted in ordinary nursery soil in three other environments and not subject to mist. Shading was arranged so as to permit 25 per cent. of full light to pass through in all cases, although the light quality may have been different between treatments. Out of doors, drainage was natural; in cold frames it was ashes over a concrete base and under the mist the media was held in mesh based boxes. Watering for the non-mist treatments was as required to keep the medium moist. Samples selected at random were examined at fortnightly intervals for root development, and the percentages of rooting cuttings according to time are given in Table XXX.

TABLE XXX
The effect of environment on the rooting of cuttings

Time from planting				Out of doors		Cold frame	Glass house with mist
				Bamboo lath shade	Cloth shade		
6 weeks	..	..	..	0	0	5.6	26.6
8 weeks	..	..	..	0	0	11.1	67.2
10 weeks	..	..	..	7.1	7.1	22.2	78.1
12 weeks	..	..	..	28.6	36.4	40.0	90.5

Rooting is expressed as a percentage of the samples examined.

The effect of mist in the glass house was to greatly accelerate the rooting rate of the cuttings.

One half of the mist was manually controlled, being in continuous operation during day light from 6 a.m. to 6 p.m.; whilst the other half was under intermittent control by electronic leaf and operated 24 hours per day. The effect of the two treatments on rooting percentage is shown in Table XXXI.

TABLE XXXI
Comparison of rooting under intermittent and continuous mist

<i>Time from planting</i>				<i>Intermittent</i>	<i>Continuous</i>
6 weeks	..	..	..	20.3	32.8
8 weeks	..	..	..	67.2	67.2
10 weeks	..	..	..	78.1	78.1
12 weeks	..	..	..	94.1	89.5

This comparison of intermittent and continuous mist shows there is very little difference between the two, but as this trial was done during the hot season the cooling effect, if any, of the extra water used in the continuous mist may not be so marked as if the trial had been carried out in the cold season. The results in the table take no account of the amount of growth produced and it may be found later that differences may occur between the two systems. It is important to note that the intermittent mist used about one tenth of the water used by the continuous mist.

Under both mist treatments, eight different media were used and their effect on rooting is shown in Table XXXII.

TABLE XXXII
The effect of rooting media on tea cuttings under mist at 10 weeks

<i>Medium</i>				<i>Ratio</i>	<i>Intermittent</i>	<i>Continuous</i>
Peat	..	..	..	—	75%	82%
Peat: sand	..	..	..	1: 1	75%	82%
Peat: sand	..	..	..	2: 1	100%	82%
Soil	..	..	..	—	86%	100%
Soil: sand	..	..	..	1: 1	86%	82%
Soil: sand	..	..	..	2: 1	100%	63%
Sand: fine	..	..	..	—	25%	50%
Sand: coarse	..	..	..	—	75%	63%

Of these media, soil (a red loam) seems suitable, is the most readily available and the most economic. Sand was poor perhaps due to its alkalinity.

The early shoot growth of these cuttings under mist was very pale in colour and it was thought that may have been due to leaching of nutrients. In April, sulphate of ammonia was applied fortnightly at 1 oz. per square yard of soil, either dissolved in the mist through an applicator or placed directly onto the soil surface. Two clones were used for this observation which was carried out during the cold season. Records of soil temperatures were taken but no differences due to the two mist treatments were recorded. Because all these cuttings are ultimately required for hardening off and eventual establishment in the field it was not practical to remove frequent samples for root observation as previously and classification was eventually made on a graded scale.

TABLE XXXIII

The percentage of cuttings according to rooting grades, under mist with and without sulphate of ammonia application

<i>S/Am. application</i>				<i>Continuous Mist</i>			<i>Intermittent Mist</i>		
				<i>nil</i>	<i>on soil surface</i>	<i>applied in mist</i>	<i>nil</i>	<i>on soil surface</i>	<i>applied in mist</i>
Rooting grade	..	..	good	7	35	54	43	47	68
	..	..	medium	35	19	31	21	17	18
	..	..	slight	25	15	8	18	18	8
Callus only				33	31	7	18	18	6

Rooting growth responded to nitrogen particularly when applied in the mist.

Experiments with *Eucalyptus Saligna*

Recent years have seen an increase in the use of coal and oil fuel for factory purposes in Nyasaland but wood fuel from blue-gums is still of major importance and commercial scale plantings take place every season. On the stations only small areas are planted but the opportunity has been taken to lay down experiments of possible benefit to the Industry.

The major 1959/60 experiment was a three-cubed factorial comparing the effects of sulphate of ammonia, single superphosphate and dieldrin at the following rates:

(i) Sulphate of ammonia supplying the equivalent of 0, 30 and 60 lb. N. per acre.

(ii) Single superphosphate supplying the equivalent 0, 14 and 28 lb. P_2O_5 per acre.

(iii) Dieldrin at the rate of 0, 1.5 and 3 lb. active ingredient per acre.

There were two complete replications, partially confounded between six blocks each of nine plots, plots being 10 trees at a spacing of 6 feet square.

Seed was sown in September, pricked out during November and planted to the field by a Hershall planter in early February, 1959. Half of the fertilizer rates were applied at planting and the other half two months later. All the dieldrin was applied at planting time. Dead plants were replaced 2 weeks after the original planting.

Survival percentages at October, 1959, are recorded in Table XXXIV and analyses were made on angular transformation of the crude data.

TABLE XXXIV

The effect of sulphate of ammonia, single superphosphate and dieldrin on survival of *Eucalyptus saligna* seedlings at 8 months after planting

<i>Treatment</i>			<i>Sulphate of ammonia (N)</i>			<i>Single supers (P_2O_5)</i>			<i>Dieldrin (a.i.) lb. p.a.</i>		
Nutrient lb. per acre	..		0	30	60	0	14	28	0	1.5	3
% Survival	..	..	89	86	86	89	83	89	80	90	91

C.V. % angular transformation, 17.1

Neither sulphate of ammonia nor superphosphate had significant effects on survival but dieldrin applications significantly increased survival over no dieldrin, ($P=0.01$). There was no significant difference between 1.5 lb. and 3 lb. a.i. dieldrin per acre and the former would appear to offer adequate protection.

An estimate of the growth of the trees was calculated by using the radius at 6 inches above soil level, height and the standard Forestry Department formula for estimating timber volume. The effects of treatments on volume are recorded in Table XXXV.

An interesting linear correlation exists between the sulphur contents of the applied fertilizers and volume of growth. Thus the regression equation of the volumes given in Table XXXV on the sulphur contents of the main treatments N and P_2O_5 is, for the six values, $V=0.2831 S+8.56$, where V is volume and S, lb. sulphur included per acre and this regression accounts for 90.88 per cent. of the sums of squares of the dependent factor. This value is significant at $P=0.01$. The dieldrin used had no sulphur content.

As far as is known this is the first record of a suggestion of a response to sulphur by *Eucalyptus saligna* and consequently in the following season's plantings at the station in Mlanje and at the Amalika Forestry Station in Cholo an experiment has been laid down which will compare the effects of urea with and without added sulphur.

EUCALYPTUS SEEDLINGS

Blue-gum seed was mixed with sand and broadcast onto seed beds during September, 1959. These beds were covered with a grass shade which was raised at intervals. In early November the seedlings were large enough to transplant into nursery beds and were spaced at 6×6 inches square. The beds were made of three media and two depths of cultivation were superimposed. The media were:

- (i) Red acid loam soil
- (ii) A mixture of loam; composted vegetation and sand, in the ratio 15:6:6
- (iii) Soil+an N.P.K. fertilizer mixture to bring the chemical nutrient level up to that of treatment (ii).

Fertilizers were added to the loam a month before transplanting. The two depths of cultivation were 12 inches and 18 inches. Dead seedlings were replaced at 10 and 20 days after planting. There were two complete replications and each plot contained 50 seedlings.

The results given in Table XXXVII are the total dry weights of shoot and root growth by plots taken 3 months after transplanting, which was the time that seedlings would normally have been moved to the field.

TABLE XXXVII
The growth of Eucalyptus seedlings at 3 months from transplanting (results in dry weight, grams per plot)

	Red soil	Compost	Soil+N.P.K.	L.S.D. $P=0.05$
Shoot gm.	29.02	62.22	79.80	34.30
Root gm.	2.88	5.88	7.77	3.63

C.V. % Shoots, 33. C.V. % Roots, 36.

Soil with the N.P.K. mixture has significantly increased shoot and root weight over soil alone ($P=0.05$). The compost mixture is not quite significantly better than soil and it would seem that the benefits of loam with N.P.K. are from the nutrient supplied rather than from the structure of the medium.

TABLE XXXV

The effect of sulphate of ammonia, superphosphate and dieldrin on total volume in cu. ft. per acre of 8-month-old blue-gums

	Sulphate of ammonia (N)			Single supers (P ₂ O ₅)			Dieldrin (a.i.) lb. p. a.		L.S.D.	
	0	30	60	0	14	28	0	1.5	0.05	0.001
Volume in cu. ft./acre	9.9	24.2	28.1	17.5	21.2	23.5	15.3	23.1	5.1	7.0
	..	..	..	..	..	..	..	..	..	9.4

C.V.%, 36

Depth of cultivation produced no significant differences.

It is interesting to note that the ratio of shoot to root weight in all treatments is nearly constant at about ten to one.

ABSTRACT OF ANNUAL REPORT OF THE BIOCHEMIST, 1959/60

DR. D. S. BENDALL

During the year 1959/60 some of the problems foreshadowed in the last report have been tackled. Central among these are questions relating to the quality of the colour produced during fermentation. The most important aspect of this is the brightness of a normal tea liquor when examined under milk. Tea tasters also attach significance to the brightness of the infused leaf, but it is only a rough guide to the brightness of the liquor, and is less amenable to experiment. However, the chlorophyll pigments in infused leaf have been investigated.

A study of the brightness of the liquors of a series of teas showed that brightness may be measured by determining the proportion of the total colour of a liquor which is extracted into a solvent (ethyl acetate) not mixing with water (confirming the work of Bradfield and Penney and Roberts). It is hoped that a simple form of this method will eventually be used on estates to control and record fermentation in the factory. Roberts has suggested that there are two main classes of pigment in a tea liquor:

- (i) Theaflavins, which are orange and soluble in ethyl acetate,
- (ii) Thearubigins, which are brown and mostly insoluble in ethyl acetate.

Brightness of a liquor is due mainly to the theaflavins, which contribute about one third of the colour in a good liquor. Thus we have two formulae to describe the colour of the liquor:

$$(i) \text{ Total colour of liquor} = \text{colour due to theaflavins} + \text{colour due to thearubigins.}$$

$$(ii) \text{ Brightness of liquor} = \frac{\text{colour due to theaflavins}}{\text{total colour of liquor.}}$$

The time-course of colour development during fermentation was studied by grinding leaf with sand, allowing it to ferment for various lengths of time, and extracting the pigments with boiling water. Brightness of the extract was low during the early stages of fermentation, increased to a maximum and thereafter declined. Total colour increased rapidly at first and then more slowly, until a maximum was reached some time after the maximum brightness. Prolonged fermentation led to loss of brightness but no increase in total colour. Thus from the point of view of colour alone there is a fairly clearly optimum time of fermentation, which would probably be shortly after the time for maximum brightness, as some loss of brightness can be compensated for by increased total colour.

The time of maximum brightness is determined by the conditions of fermentation and probably also by the polyphenol oxidase activity of the leaf. The degree of brightness attained at the maximum depends on the chemical constitution of the leaf, for example the proportions of the individual polyphenols in the leaf might be involved rather than the total concentration, or perhaps the amount of caffeine. Present research is directed towards an elucidation of these factors. The addition of various substances at the beginning of fermentation to leaf ground with sand has been found to influence the brightness of the subsequent hot water extract. The most promising effect so far has been obtained by a controlled acidification of the leaf with acetic acid which caused an increase in brightness without much effect on the total

colour. Acetic acid would probably be driven off during firing, leaving no taint, but extensive trials with the miniature manufacturing plant at the Tea Research Station, followed by factory trials, will be necessary before any general recommendations can be made.

Analyses on a series of bushes have shown that when fermentation is measured by extraction of the fermented leaf with boiling water, the total colour developed depends on both the polyphenol oxidase activity and the total polyphenol content of the green leaf. Last year it was reported that when measuring the colour in extracts of fermented leaf made with cold solvents the total colour depends on the oxidase activity but not on the total polyphenol content. These and other results suggest that firing in normal manufacture is an important stage in colour development. For experimental purposes extraction of fermented leaf with boiling water is probably more closely related to normal manufacture than extraction with cold solvents, but further comparisons of the two methods may give useful information. Oxidase activity and polyphenol content, therefore, are both important, but since oxidase activity is the more variable, poor fermentation is normally due to a deficiency of the enzyme, as found last year. The polyphenol oxidase activity and total polyphenol content of samples from three high quality Ceylon clones were within the range found in Nyasaland leaf.

Experimental evidence has been obtained to confirm the suggestion made last year that the main change in the chlorophyll pigments of the leaf during manufacture is a conversion of the bright green chlorophyll into the dull olive-green phaeophytin by loss of magnesium from the molecule. The colour change involved can easily be observed when fresh tea leaves are dropped into boiling water. Actually black tea, in addition to phaeophytin, still contains a considerable proportion of unchanged chlorophyll, but this is practically all converted into phaeophytin during normal infusion. In a good tea the phaeophytin colour of the infused leaf is masked by the brown phenolic pigments. Although a greenish infused leaf may result from an excessive concentration of phaeophytin, uneven fermentation is a more likely cause.

There is little destruction of chlorophyll during fermentation under experimental conditions, save for a partial conversion into phaeophytin. Comparison of the results obtained for a mixed sample of made tea (Typhoo) and various samples of fresh leaf, suggests that during the overall process of manufacture about 20 per cent. of the chlorophyll may be destroyed, but this is only an approximate figure. There is no evidence to suggest that Nyasaland leaf in general contains exceptionally high concentrations of chlorophyll, but an artificial stimulation of chlorophyll break-down might be beneficial in some cases.

The chemical constitution of the tea leaf is genetically determined, hence the importance of selection and breeding. Nevertheless the actual concentrations of substances, for example polyphenol oxidase, are unlikely to be entirely a matter of inheritancy; there is evidence at least in other plants that environmental factors, such as climate and the availability of minerals in the soil, have an appreciable influence. Analyses of ash obtained from selected good and poor fermenters suggested that poor fermenters are low in phosphorus, but have relatively high contents of iron, copper, nickel, silver and titanium, but confirmation of these results is needed. Such confirmation will be sought by further analysis of leaf samples and made tea from the N.P.K. fertilizer experiment on mature Indian bushes which has been in progress at Swazi for the past eight years.

The work in Cambridge is now developing in two principal directions. On the one hand the factors governing the development of theaflavins and thearubigins during manufacture, and the relative proportions of the two pigments, are being studied. The results described above show how information of practical value can

be obtained in this way. On the other hand, Mr. R. P. F. Gregory started work in October, 1960, on the purification of the polyphenol oxidase from tea leaves. Eventually the properties of the purified enzyme will be studied, and a knowledge of these will help in understanding the detailed mechanism of colour formation in fermenting leaf. Further estimations of chlorophyll and phaeophytin in Nyasaland and other teas are still required and a search for methods of stimulating chlorophyll breakdown. The relations between the mineral status of the tea bush and quality are being followed up in collaboration with the Agricultural Chemist and the staff of the Tea Research Stations.

SUMMARY

1. A method for measuring brightness of tea liquors has been described.
2. The time-course of colour development during fermentation shows that there is an optimum time of fermentation to obtain maximum brightness.
3. The brightness of the liquor can be improved by the controlled addition of acetic acid to the leaf at the beginning of fermentation.
4. The above observations suggest practical applications in the factory.
5. The total colour produced during fermentation depends on the polyphenol oxidase activity. It also depends on the total polyphenol content when the fermented leaf is extracted with boiling water, but not when it is extracted with cold solvents; the former method is more similar to normal manufacture, which suggests that firing is important in colour development.
6. During manufacture and subsequent infusion of the made tea the bright green chlorophyll of the fresh leaf is converted into the dull olive-green phaeophytin by loss of magnesium from the molecule. Apart from this there is little destruction of chlorophyll during manufacture.
7. The two main directions of research in Cambridge at present are a study of the factors governing the development of colour and brightness during fermentation, and the purification and study of the polyphenol oxidase from tea leaves.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

The increasing development of tea growing in Rhodesia led to enquiries from the Federal Ministry of Agriculture, regarding tea soils, nutrient status and fertilizer recommendations. Data on soil and leaf composition, fertilizer use etc. were made available and subsequently discussed with their Chemistry Division.

Dieback of tea seed bearers on a Mlanje estate was found to be due to white ant attack, and not to any inherent soil factor. This had been aggravated by clean weeding, during which appreciable amounts of top soil had been removed. The use of dieldrin, slashing and mulching was recommended.

Elsewhere, appreciable dieback and slowness in coming away after prune, could not be attributed to a soil factor itself, but the tea concerned was in a slight depression, where in normal times, the water table would be relatively high, even in the dry season. The root system would thus not need to extend as deep as usual. This was confirmed by root excavations, the tap root not extending much below three or four feet. Thus, the recent drought conditions would have lowered the water table below the usual limit, and as the bushes had a long established main root system, they were unable to accommodate themselves to the new conditions, with the above results noted in the field.

There was also an appreciable amount of dieback of *Grevillea* shade trees, which again was probably a delayed effect of the drought as the boron level was 37–51 p.p.m., higher than reported on leaf where boron deficiency was found in East Africa. On one estate, however, this was particularly marked in an area which had been cleared for replanting, the original shade trees having been left in preparation for the new establishment. Examination of a selection of those which were still dying, showed that in all cases the trees were completely ringbarked, apparently by ants. All other trees showed partial ring-barking. This could be explained either by scorching due to the sudden exposure to sun and wind of the bark, previously closely protected by tea bushes, or the bark might become susceptible to attack due to weakness of the trees, caused by cessation of fertilizer application, when the tea was abandoned, and also by subsequent competition from grass and weeds. Examination of another block of recently abandoned tea, just below the “replanting” area indicated that here also the *Grevillea* trees were dying back, and there was appreciable ringbarking. As the abandoned tea had not yet been uprooted the exposure theory would not apply, and it appears that the nutrient aspect is possibly the main one. This received additional support, from the fact that in a block of tea just across the road, but receiving 70 lb. N/acre, the *Grevillea* shade trees were vigorous, with good green leaves, and among a selection of trees examined there was no ring-barking apparent.

For further clarification, samples of *Grevillea* leaf from these various blocks were taken for determination of nitrogen content, the figures being:

Details				Nitrogen per cent. on dry matter
Replanting area	Yellow leaf from ringbarked trees	..	..	0.98
Replanting area	Leaf from improved trees after fertilizing	..	..	1.34
Abandoned area	Yellow leaf from ringbarked trees	..	..	1.10
	Leaf from opposit area + 70 lb. N	..	..	1.81

It is therefore clear that the nitrogen factor was quite significant, and it appears that in areas of abandoned tea, if the *Grevilleas* are to remain, then they should be given applications of nitrogen, until such time as the area is replanted, and the tea is receiving appreciable amounts of nitrogen itself. A series of tests to cover the shade effect, and the fertilizer aspect were recommended.

Several new areas were surveyed for development and the usual pattern of soils was found, from which the deep loams derived from basic rock were selected wherever possible. The most important development was the proposal to investigate irrigation of tea on a large estate in the Northern Province, and two pilot sites for this were selected. A Mlanje estate wished to use another estate in the Blantyre area, for an isolation seed bearer garden. In this lower rainfall area, the soil pH was rather high, and the soil was less well developed, and texturally less suited than are the Mlanje soils.

The causes of poor growth and dieback in one field of a Cholo estate were investigated. This field was planted in the same period and with stumps from the same nursery as other fields. The affected field was, however, the last field to be planted and, though the difference in time between the first and last planted fields was small, it appeared to have been the underlying cause. The first stumps taken from the nursery would be those of optimum size and the last may have been unduly large. These large stumps would also have had a few weeks less to become established before the onset of the March–April drought. These two factors acting together were probably enough to cause the damage.

At another nursery, where patchy chlorosis was observed, the nitrogen in the leaf of affected bushes was low (2.5 per cent.) compared with the general level (4.1 per cent.), and in the absence of any other nutrient or root factor, it appeared that uneven distribution of fertilizer was involved.

The anomalous relationship between base capacity, exchangeable hydrogen and total bases, which had been observed in soils of pH appreciably less than 5.0 i.e. c. 4.3–4.6, was investigated by determination of exchangeable aluminium. The amount of this element did not account for the difference—which now appears due to the difference between the base capacity as determined at pH 7 in the normal laboratory process, and its value at the more acid field conditions. For example, two soils of pH 4.3 and 4.5 respectively, had base capacities of 13 and 16 when leached with ammonium acetate at pH 7, but when the leaching solution was acidified with acetic acid to pH 4.5, the respective capacities were then 9 and 11.

SOIL NUTRIENT CHANGES UNDER TEA

In previous years reference has been made to the potassium status of tea soils, with particular reference to the apparent adequate rate of mineralization to keep pace with removal in the tea leaf. Further examination of this aspect has been made by an examination of soils from the NPK experiment at Swazi Station. These plots were first sampled separately in 1951, and a comparison was made by resampling in 1959. The data on top soils shown below, refers only to the lowest and highest level of treatment, the first figure referring to 1951, and the second one of each pair to 1959.

Fertilizer applied lb.			N		P ₂ O ₅		K ₂ O		L.S.D.
			40	120	0	60	0	60	
pH	1951	..	5.1	5.1	5.1	5.1	5.1	5.1	0.1
	1959	..	5.0	4.6	4.8	4.8	4.9	4.8	
P	1951	..	21	24	21	24	20	24	23
ppm	1959	..	98	105	67	137	111	101	
K	1951	..	Range		.20–.42		Mean	.29	.06
mge/100	1959	..	.34	.22	.29	.28	.26	.33	
N%	1951	..	.11	.11	.11	.11	.11	.11	
	1959	..	.18	.18	.18	.18	.18	.17	
C%	1951	..	1.7	1.7	1.8	1.8	1.7	1.7	
	1959	..	2.9	2.9	3.0	3.0	2.8	2.9	

The results indicate the expected decrease in pH due to sulphate of ammonia, but as there was no control plot without this fertilizer the contribution of normal weathering in this effect cannot be assessed. The organic matter, nitrogen, and phosphate has increased on all plots, the latter especially so at the higher level of this nutrient. On the basis of the general level of K, there has been no appreciable change, except that the highest level of N gives the lowest K level. Although nutrients would accumulate in the top soils, as the organic matter increased, this might lead to a depletion at depth, which would not be reflected in the data shown above. Samples to a depth of 14 feet were taken from individual plots, and although this investigation is still in progress it may be reported that there was a sharp decrease in available phosphorus from 60–100 ppm in the top soil to 20–25 at one foot and 10–15 at 3 feet. This figure remained fairly even to 14 feet. Similarly the potassium fell to about 50 per cent. of the top soil level at one foot, and then to about 0.03 at 3 feet, remaining at this level to depth. Determination of total P and K, and mineralization rates will help to resolve this problem.

ARBORICIDE TRIALS

Ringbarking trees, to deplete starch reserves before uprooting—as a preventive action against *Armillaria mellea* attack—is universal on tea estates. This means, however, a two year wait before clearing, and the practicability of using arboricides

to accelerate starch depletion has been examined. Treatments were applied in September. The number of months to apparent death (Roman numeral) and the starch content of the roots nine months after treatment are summarized below but the seasonal variation for each species, and the final effects are still under examination.

Species	Control	Ringbark	2.4.D (5%)	2.4.5.T (5%)
<i>Afromosia</i>	— 10	— 10	VII 6	III 1
<i>Cussonia</i>	— 3	VII 1	III 1	IV 2
<i>Erythrina</i>	— 20	II 7	IV 7	IV 7
<i>Isobertlinia</i>	— 9	— 8	VI 11	V 2
<i>Parinari</i>	— 5	— 1	II 1	II 1
<i>Pterocarpus</i>	— 10	IV 1	IV 3	II 6
<i>Uapaca</i>	— 3	— 1	VII 1	VII 5

A further trial on the *Grevillea* shade trees, which periodically require thinning or replacing in tea gardens has also been made. In this instance split successive applications at lower levels are being made to see if this will produce a more rapid result than a single application, even if at a higher level. Thus applications are 6 per cent., two at 3 per cent., and three at 2 per cent. Data on starch content two months after application indicate that the control roots contained 10–11 per cent., while those on the ringbarked trees was reduced to 5–6 per cent. The 6 per cent. applications of 2.4.5.T had less effect than the lower concentrations, reducing the starch to 8 per cent., while at 3 per cent. strength it was 3 per cent., and 2 per cent. strength, 3.5 per cent. starch. 2.4.D at all levels reduced the starch to 3.5 per cent. An additional arboricide, trichloro-benzoic acid (TBA) was used and had a similar effect to 2.4.5.T, the starch level at 6 per cent. application being 5 per cent., and 2–3 per cent. at the lower rates. The content of sugars with all treatments was 0.5–0.8 per cent.

These results have been based on the determination of carbohydrates by anthrone, and the established methods for extraction have been modified to speed up the determinations. Checks on the distribution within roots have also been made.

TEA FERMENTATION

During Dr. Bendall's stay in the laboratory, various data was obtained on the copper contents of tea from different bushes, and also after copper injection. The latter figures reflected less uptake than would have been expected. Samples of fresh leaf from selected fermenters and non-fermenters have been sent to Cambridge for examination and several estates have become more interested in fermentation assessment either by the "mincing" or chloroform method. Following the finding that the low polyphenol oxidase activity is the main cause of the poor rate of fermentation of Nyasaland teas, samples of extracted enzyme have been prepared and sent to Cambridge periodically for activity measurements.

Extract from Report of the Plant Pathologist

Armillaria mellea (Fr.) Quel. still causes a certain amount of damage. An outbreak occurred in a 30-year-old field after ringbarking of shade trees prior to removal. Fructifications were found at the base of tea bushes infected in this outbreak. No rhizomorphs were noted, infection of the tea having apparently come from contact of the tea roots with infected roots of the *Grevillea robusta* shade trees.

A survey conducted by G. C. Martin, Senior Helminthologist of the Federal Ministry of Agriculture, revealed the presence of rootknot nematodes, *Meloidogyne* spp. in all but one tea nursery in the Cholo/Mlanje area. *M. javanica* was the commonest, being found in 70 per cent. of the nurseries; the remainder of the nurseries were, with one exception infected with *M. incognita* var *acrita* Chitwood, found to be infected with *M. arenaria* (Neal) Chitwood. Although considerable damage was done by these nematodes in the nursery, little or no damage was found in mature plantings.

TUNG

1. Production of Improved Planting Material

1. BUDTINGS VERSUS SEEDLINGS

Object—This experiment at Bvumbwe compares:

1. Scions from four *montana* selections budded on *montana* seedling stocks,
2. Scions from four *montana* selections budded on *fordii* seedling stocks,
3. Seedlings from four *montana* selections,
4. Unselected *montana* seedlings.

It thus compares four *montana* mother trees budded on to *fordii* and *montana* rootstocks, the same four mother trees propagated from open pollinated seed and unselected seedlings. The selections were from A-type trees, which are vigorous in habit.

Design.—The four treatments are replicated six times in six randomized blocks, each plot containing twelve trees—planted at a spacing of 28 feet × 28 feet (56 trees per acre). The experiment was planted in November, 1940, and covers 5½ acres.

The trees are fertilized yearly with sulphate of ammonia at the rate of 3 lb. per tree (168 lb. per acre) except every sixth year when they receive an equivalent amount of nitrogen as tung cake at 30 lb. per tree. The first crop was harvested in the third year, 1943, and was a small one mainly from the buddings.

TABLE I
Buddings versus Seedlings, 1940-1960*
(Yield in lb. air dry seed per acre)

Treatment		Mean Yield per year						Mean 20 years	
		1943-46	1947-50	1951-54	1955-58	1959	1960	per tree	per acre
		3-6 yrs. old	7-10 yrs. old	11-14 yrs. old	15-18 yrs. old	19 yrs. old	20 yrs. old		
Age									
Montana Stock	..	254	1,512	1,925	1,642	1,798	2,710	29.3	1,640
Fordii Stock	..	167	1,051	1,505	1,533	1,646	2,537	25.1	1,407
Selected Seedlings	..	120	836	1,320	1,028	1,170	1,484	17.7	993
Unselected Seedlings	..	104	678	911	843	902	1,411	14.4	808
Mean	..	161	1,019	1,415	1,262	1,379	1,576		
		Lowest Sig. Diff. (p=0.01)				582	918		
		Coeff. of Variation				48.0%	22.5%		
Buddings on montana stock									
M.8	..	250	1,645	2,157	1,772	1,691	2,682	30.4	1,700
M.13	..	317	1,765	2,081	1,789	2,117	2,806	32.4	1,813
H.14	..	263	1,552	2,001	1,729	1,758	2,845	30.2	1,691
F.9	..	187	1,084	1,504	1,228	1,204	2,514	23.0	1,287
Buddings on fordii stock									
M.8	..	135	910	1,546	1,515	1,730	2,341	24.3	1,363
M.13	..	160	1,102	1,592	1,462	1,988	2,268	25.5	1,429
H.14	..	188	1,133	1,633	1,674	1,148	3,209	26.8	1,498
F.9	..	167	1,061	1,390	1,470	1,730	2,313	23.9	1,339

Lowest Sig. Diff.

Not Sig.

454 (P=0.05)

312 (P=0.01)

*The first crop was harvested in 1943. From 1940-1942 growth measurements were recorded and are not shown here.

The experiment has shown over the years (see Table I) that buddings from selected clonal material were significantly higher yielders than seedlings. Seedlings from selected trees gave higher yields than unselected trees. It was on the results of this experiment that all recent plantings of tung consist of clonal material. Selections budded on *montana* seedling rootstocks yielded better than when propagated on *fordii* seedling stocks except the poor-yielding selection F.9 which occasionally produced a better crop on *fordii* stock. It has been suggested that *fordii* stock is more resistant to *Armillaria mellea* root disease than *montana* but this is not proved in the experiment where there have been six vacancies due to *Armillaria* with buddings on *montana* and seven on *fordii*.

The experiment remains interesting as a study of the longevity of tung. Good yields were obtained from buddings in the sixth year from planting. Yields increased annually to the thirteenth year. At that stage the lower branches were removed to facilitate tractor cultivation. There was also a considerable amount of dieback due to attacks of the disease *Botryosphaeria ribis* and drastic pruning of infected branches was necessary to check it. Thus from 1954 there was a reduction in yield. The trees gradually recovered and yields reached a new peak in 1960, twenty years after planting.

The average annual yield for twenty-year-old trees, from which 18 crops have been harvested is over 1,600 lb. per acre of dry nuts for buddings on *montana* stock. This is very high when compared with yields in commercial tung plantations as a whole. If selected clones are planted, higher yields can be expected. Thus M.13 gave an average of over 1,800 lb. per acre.

2. LEGITIMATE SEEDLING FAMILIES

More recently higher yielding clones have been selected at Bvumbwe from neighbouring estates and details of these have been given from time to time (1957-58 Report). The collection of legitimate seedling families (crossed and selfed *montana* B-type and vigorous B-type seedlings) contains over 1,500 individuals and has yielded several trees outstanding enough to form a nucleus of mother trees for future propagation. Table II shows the yields of trees from which clonal material has been selected to plant in observation plots. Because they are dwarfer and more precocious than the A-type trees, the spacing was reduced to 25 feet $\times$ 25 feet or 70 trees per acre.

TABLE II

Performance of Selected Seedling Trees from Legitimate Seedling Families of B-type Montana Tung (lb. air dry seed per acre)

Parentage	Tree Number	Mean yield per year, 1955-1958	1959	1960	Mean, six years' crop	
		Age, 3-6 years	7 years	8 years	per tree	per acre
9 Selfed	67	588	924	1,225	13.0	912
	116	637	896	1,309	13.5	947
	127	434	1,099	1,288	13.4	940
	128	525	945	987	11.7	819
9 × 04	1,178	595	896	1,687	15.1	1,059
10 × 9	738	616	840	889	11.2	782
	741	511	861	910	10.9	761
10 × 14	885	616	1,554	1,316	16.6	1,162
	924	567	1,421	1,246	15.4	1,078
14 Selfed	277	504	1,015	1,631	15.0	1,050
14 × 10	358	826	1,379	1,750	18.8	1,318
	360	553	1,015	1,463	14.4	1,010
E464 × 14	189	532	1,169	1,330	14.4	1,010
	227	735	1,211	2,240	19.9	1,395
	248	924	511	2,331	17.9	1,255
Mean		610	1,049	1,440	14.7	1,033
Yield of trees from Table I		3-6 years	7 years	8 years		
Buddings on Montana stock		254	823	1,193	13.5	757
Selected Seedlings ..		120	414	627	6.9	387

In the first four years of bearing (age 3-6 years in the above Table) mean yields were considerably higher than from selected seedlings or buddings in the twenty-year-old experiment. The mean yield per tree for six years was usually higher than buddings of selections made in 1940. At the closer spacing the calculated yield per acre would be still higher. Although there are now no new plantings of tung, growers could well make use of material from these trees for infilling vacancies.

2. Fertilizer Trials

The only fertilizer trials still being recorded are one at Bvumbwe and one at Mzuzu.

1. N.P.K. Cu. Zn.

The object of the experiment at Bvumbwe was to test the response of tung to five fertilizer treatments, nitrogen, potash, phosphate, copper and zinc. Copper and zinc deficiency symptoms had been detected in young tung. The experiment was planted in December, 1947, with trees at a spacing of 28 feet × 28 feet (56 trees per acre).

Layout.—2⁵ factorial with two replicates 9 trees per plot with plots split to contain three trees each of the three clones M.13, 10 and C2A. C2A proved to be male and trees had to be topworked in 1953/54 with E460 in one replicate and C946 in another.

Treatments—

N.	— sulphate of ammonia,	3½ lb. per tree (196 lb. per acre)
P.	— single superphosphate,	2½ lb. „ „ (140 lb. „ „)
K.	— muriate of potash,	1¼ lb. „ „ (70 lb. „ „)
Cu.	— copper sulphate,	3 oz. „ „ (10½ lb. „ „)
Zn.	— zinc sulphate,	1 oz. „ „ (3½ lb. „ „)

TABLE III
N.P.K. Cu Zn Trial, Bvumbwe
(Yield air dry seed, lb. per acre)

	O	P	K	Cu	Zn	Mean
O	1,029	1,178	1,059	1,187	2,127	1,316
N	1,874	2,464	1,744	2,313	1,714	2,022

L.S.D. $p=0.05$ 411
 $p=0.01$ 571 Coefficient of Variation 40.2%

This year's results show (Table III), as in all previous years, that there was a significant response to nitrogen. There was also, for the first time, a response to phosphate in the presence of nitrogen and, on the second occasion, to copper in the presence of nitrogen. Potash produced a depressing effect.

The yields of the clones in the sub plots (Table IV) show the value of topworking. E.460 appears to be a particularly valuable clone.

TABLE IV
Yield of Clonal Sub-plots in Fertilizer Experiment

Clone		Yield, dry nuts per acre		Remarks
M.13	..	1,658	..	A-type
10	..	1,465	..	Vig. B-type
E.460	..	2,260	..	A-type } topworked
C.946	..	800	..	A-type } 1953/54

2. N.P.K.

The experiment at Mzuzu tests the response to nitrogen, phosphate and potash.

Layout.— $4 \times 4 \times 2$ factorial with two replicates. Six trees per plot with plots split to contain three trees each of the two clones, 04 and C2A. As in the preceding experiment, C2A proved to be male and was topworked in 1954 with M.13.

Treatments—
N. — 0, 1, 2, 3. — 0, 1, 3 and 6 lb. sulphate of ammonia per tree,
P. — 0, 1, 2, 3. — 0, 1, 2 and 3 lb. single superphosphate per tree,
K. — 0, 1. — 0, 1 lb. muriate of potash per tree.

There was a significant response to nitrogen only.

TABLE V
N.P.K. Trial, Mzuzu
(Yield air dry seed, lb. per acre)

	P_0	P_1	P_2	P_3	Mean
N_0	1,100	1,607	1,047	1,451	1,301
N_1	2,189	2,043	1,854	1,705	1,948
N_2	2,230	3,079	1,399	2,163	2,218
N_3	3,174	2,702	3,320	2,823	3,005
Mean	2,173	2,358	1,905	2,038	

L.S.D. means $P=0.05$ 835
 $P=0.01$ 1,120 Coefficient of Variation, 54.9%

3. Other Experiments with Tung

Recent investigations with tung have been concerned with

- (i) means of supplementing the growers' income on an established plantation,

(ii) increasing the yield per acre by planting B-type trees at a close spacing and

(iii) reducing the cost of maintenance of a newly-established plantation by planting an intercrop.

I. PASTURES UNDER TUNG

Two possible ways by which a grower could supplement his income from an established plantation are

(i) to interplant his trees with some other tree crop such as coffee,

(ii) to interplant with a pasture and graze it with cattle or sheep.

The growing of coffee between tung is discussed briefly in the section on coffee.

At Bvumbwe a pasture of *Paspalum notatum*, which had been found to take water only from the superficial layers of soil, was planted in an established tung fertilizer experiment which had been planted in 1940. The layout was a randomized block design with six replicates. The strains of *P. notatum*—Pensacola and Paraguay—were planted each in two blocks at 18 inches×18 inches and 36 inches×36 inches in April, 1958.

The trees provided an almost closed canopy and the grass grew slowly. In January, 1959, the branches of the tung trees were trimmed to five feet from the ground. The grass then grew more vigorously and was ready for grazing by July, 1959. Black-faced Persian ewes and a Dorper (Dorset×Persian) ram were introduced.

Fertilizer treatments: sulphate of ammonia was broadcast under the trees at the rate of 0, 2, 4 and 6 lb. per tree (0, 112, 224 and 336 lb. per acre).

TABLE VI
Paspalum in a Nitrogen Fertilizer Experiment with Tung
(Yield of air dry seed, lb. per acre)

Treatment	S. of A, lb. per tree	Mean 1956-57	1958	1959	1960	Mean
A—Clean Cultivation ..	0	1,114	1,411	554	678	941
	2	2,050	1,618	1,042	1,439	1,674
	4	1,400	1,613	846	1,198	1,266
	6	1,954	2,195	1,081	1,574	1,702
Mean A		1,630	1,848	879	1,221	1,394
B—Clean Cultivation up to 1958; Paraguay Paspalum thereafter	0	935	1,170	588	722	857
	2	1,876	2,027	711	1,238	1,462
	4	2,486	2,542	935	1,277	1,809
	6	2,106	2,486	1,036	1,602	1,809
Mean B		1,848	2,055	818	1,210	1,484
C—Clean Cultivation up to 1958; Pensacola Paspalum thereafter	0	1,327	890	487	577	823
	2	1,467	1,439	969	834	1,176
	4	1,971	2,750	762	1,714	1,798
	6	1,501	1,546	969	1,120	1,282
Mean C		1,568	1,658	795	1,058	1,271
Mean all treatments ..		1,682	1,854	831	1,163	1,383
L.S.D. main treatment means, P=0.05		Not Sig.	Not Sig.	Not Sig.	Not Sig.	162
L.S.D. fertilizer P=0.05		—	657	280	368	285 (P=0.01)

The 1959 yield fell in all plots to about half that in 1958. This was a result of the pruning operation. The decrease in yield was greatest in the grassed down plots. Yields of tung in sections B and C which had been greater or not significantly lower than that in section A were, after grassing down, both significantly less. The *Paspalum* appeared to have had a slightly depressing effect even in the plots receiving high fertilizer dressings. In 1960 overall yields had begun to rise, the trees recovering from the effect of pruning.

An advantage of grassing down a mature plantation is that cultivation costs are reduced. The experiment has been mown infrequently, mainly to check weed growth during the establishment period. The grass was evidently assisted in establishment when the lower tung branches were pruned.

The mean live weight of the Persian $\times$ Dorper wethers was 64.3 lb. at six months. This compares favourably with Persian $\times$ Native type wethers bred at Tuchila which weighed 49.9 lb. and they, themselves, produced larger carcasses than pure-breed Black Faced Persians.

The system of establishing a pasture in mature tung and grazing it with sheep is an attractive means by which a tung grower may supplement his income. The mutton would find a ready sale.

2. B-TYPE TUNG AT A CLOSE SPACING

Objects.—To observe at Bvumbwe how quickly a close-planted plantation of dwarf, precocious, B-type tung can come into economic bearing, its longevity and to determine the optimum spacing. The site of the experiment was previously planted to rhodes grass ley and lay fallow for one year. The trees were planted in December, 1957.

Layout.— 3×2 factorial with five replicates. Spacing is at three levels (7 feet 6 inches, 10 feet and 15 feet) and the plots are interplanted with and without A-type trees at a 30 feet spacing. The plots of the experiment were planted with buddings of B-type clone 9 and the vigorous A-type clone V17. The guard rows were planted with buddings of the B-type clone N4 and A-type V17.

Treatments:

1. 7 ft. 6 in. spacing B-type,
2. 7 ft. 6 in. interplanted with A-type,
3. 10 ft. spacing B-type,
4. 10 ft. interplanted with A-type,
5. 15 ft. spacing B-type,
6. 15 ft. interplanted with A-type.

As usual, the first crop was obtained when the trees were in their third year in the field. V17 yielded a negligible quantity.

TABLE VII
Close-Spacing Trial, 1960
(Mean yield, lb. air dry seed per acre)

	Spacing			Mean	L.S.D. (spacing)
	7'6"	10'	15'		
Pure-Stand B-type	429	185	100	238	p=0.01 183
Interplanted with A-type	296	178	102	192	p=0.05 126
Mean	362	182	101		

Coefficient of Variation = 66%

The closest spacing of 7 feet 6 inches gave a significantly greater yield per acre than the two wider spacings. There was no significant difference between pure-stand plots and those which had been interplanted with A-type trees. The yield per acre was higher than normally obtained from trees in their first year. The closest spacing forms such a canopy that, although not yet closed, is sufficient to suppress weed control and reduce cultivation costs. Although the cost of planting material is high, the savings in cultivation costs and high yield per acre make this system of growing tung very attractive.

3. INTERCROPPING IN TUNG

Previous experiments have demonstrated that satisfactory growth is only obtained if fairly thorough cultivation is given during the first 4 or 5 years. An experiment with different intercropping treatments was planted in December, 1954, designed to test the effect of tung once it was established. The tung trees were circle-weeded during the period of establishment and have borne two small crops. It is too soon to expect any difference in the tung yields between the treatments and none has yet reached a significant level.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

TUNG OIL

STATUTORY ANALYSIS OF EXPORTED OIL

The improved market position has encouraged greater production; and more seed has been processed. A record total of 1,329 tons was exported, the distribution being as follows:

<i>Great Britain</i>	<i>Africa</i>	<i>Japan</i>	<i>U.S.A.</i>	<i>Europe (not U.K.)</i>	<i>Australia</i>	
552	309	275	90	84	19	tons
42	24	21	7	6	1	%

The proportion of *fordii* oil continues to decrease, and this year was only 13 tons, less than 1 per cent. of the total.

COMPOSITION OF TUNG OIL

One factory was still producing a proportion of acid oil, but advice on seed storage and harvesting control has improved this, and in the current season acidity at all factories is being maintained below 1 per cent.

A certain amount of seed from some smaller estates has not been well stored and rejection has been advised to the factories, as it is essential to maintain quality standards for the oil in the present economic situation.

Data has been supplied to the British Standards Institute in connection with the modification of the B.S.S. for tung oil, particularly with regard to the reintroduction of a modified Worstall Heat Test, and the corresponding polymerization data on *montana* oil.

TUNG OIL UTILIZATION

The work carried out by Dr. Chatfield on behalf of the Nyasaland Government has confirmed previous findings that there is no difference in durability of varnishes produced from *montana* and *fordii* oils. Valuable data has been obtained in addition, showing that the additional *montana* oil required to equate the eleaostearic acid in the *fordii* oil, can be considerably reduced by slight modifications in the processing time and temperature. In some instances, in alkyd and phenolic formulations, the *montana* oil has shown definite advantages, related to its slower reactivity and possibly more stable esterification due to the lower content of trielaostearin.

COFFEE

The species of coffee grown is *C. arabica*. Unless it is stated otherwise, the experiments are situated at Bvumbwe. The coffee experiments are sited on the deep medium to heavy clay loams which are uniform in texture to a depth of 10 feet or more. The plots are level or on moderate slopes of not more than 5 per cent. The boundaries are planted with windbreaks of a double line of pines (*Pinus patula*) at a 12 foot staggered spacing. *Tephrosia* and bananas provide shelter until the pines have grown. Areas over four acres in size are subdivided by a further shelter belt of a line of *Grevilleas* planted between two rows of bananas.

1. Cultivation and Manurial Trials

1. SHADE/MULCH/MANURIAL EXPERIMENT

Site.—Originally planted to a tung spacing experiment, then to a linseed crop. Considerable sheet erosion had taken place.

Planting.—Coffee was planted in December, 1953, at a spacing of 9 feet $\times$ 9 feet (537 trees per acre) with the variety KP.228.

Pruning system.—Multiple stem.

Object.—

1. To investigate the effect of a leguminous and non-leguminous shade,
2. To investigate the effect of surface mulch,
3. To determine the response of coffee to nitrogenous, phosphatic and potassic fertilizers,
4. To study the interaction of these materials.

Layout.—4 $\times$ 4 Latin Square with 36 trees per plot. The main plots are split into four sub-plots of nine trees each to contain an N.P.K. factorial experiment.

Treatments.—Main Plots—

(1) *Grevillea* shade, mulched with napier.

S. *Albizzia* shade, mulched with tung hulls.

SM. *Albizzia* shade, mulched with napier.

M. No shade, mulched with napier.

The shade trees were planted nine months before the coffee. The leguminous shade was at first *Sesbania* which was to be removed when the *Albizzias* had grown. But they competed adversely with the coffee and had to be removed within the second year. Similarly bananas were to provide a temporary non-leguminous shade until they could be replaced by *Grevilleas* but had to be removed within the third year. Plots (S) and (1) were not mulched for the first two and three years respectively.

Sub-plots—

N. sulphate of ammonia 4, 6, then 8 oz. per tree in third and subsequent years.

P. single superphosphate 4, 6, 8 oz. per tree etc.

K. muriate of potash 3, 4 oz. per tree etc.

Results.—The experiment has now completed its first cycle. Four crops were taken in the years 1957–60 and the yields are shown in Table I.

TABLE I
Shade and Mulch in Coffee, Bvumbwe
(Yield, clean coffee, lb. per acre)

<i>Treatment</i>				1957	1958	1959	1960	<i>Mean</i> 1957-60
M	..	..	..	815	734	1,960	2,021	1,382
SM	..	..	..	104	461	963	1,684	803
(1)	..	..	..	82	308	661	1,922	743
S	..	..	..	39	488	482	1,283	573
L.S.D.	P=0.05	..		711	267	358	657	430
	P=0.01	..		766	308	544	—	618
Coeff.	of Var.	..		39.3%	15.8%	10.2%	11.0%	30.7%

This was the first experiment to be planted and therefore of great importance in determining the cultural requirements of coffee in Nyasaland. It has demonstrated that:

1. Mulch is essential for coffee grown in the climatic conditions of the Shire Highlands.

2. Temporary shade trees of *Sesbania* and banana should not be interplanted in coffee because they compete with it for moisture.

3. The effect of the permanent shade trees of *Albizzia* and *Grevillea* cannot yet be finally assessed because the coffee trees have taken so long to recover from lack of mulch or competition from temporary shade trees. In 1960, for the first time, there was no significant difference between the yields from the unshaded and the *Grevillea* shaded plots.

4. The experiment has confirmed that, given good standards of cultivation, coffee can be grown without irrigation. Yields of over 7 cwt. of clean coffee per acre can be expected and, under the most favourable conditions, a mean yield of over 12 cwt. per acre was obtained for the four crops in the first cycle.

In 1960 there was a more marked response to fertilizers than in any other year.

TABLE II
Effect of Fertilizers on Shade/Mulch Experiment, 1960
(Yield, clean coffee, lb. per acre)

<i>Fertilizers</i>				(1)	P	K	PK	<i>Mean</i>
No Nitrogen	..	..		1,721	1,576	1,762	1,543	1,650
Nitrogen	..	..		1,897	1,489	1,775	2,056	1,804
<i>Interaction</i>				M	SM	(1)	S	<i>Mean</i>
No Nitrogen	..	..		1,976	1,566	1,912	1,148	1,650
Nitrogen	..	..		2,066	1,802	1,931	1,418	1,804
No Phosphate	..	..		2,008	1,731	2,088	1,329	1,789
Phosphate	..	..		2,034	1,637	1,755	1,237	1,666
No Potash	..	..		1,918	1,771	1,753	1,240	1,671
Potash	..	..		2,123	1,597	2,090	1,325	1,784

Least Significant Differences:

Fertilizers .. P=0.05—110
P=0.01—149

Interactions P=0.05—220
P=0.01—298

There was a significant increase due to nitrogen (see two-way fertilizer table in Table II) except in the presence of phosphate. The effect of phosphate is that the mean yield decreases from 1,789 lb. to 1,666 lb. of clean coffee per acre. In the case of potash there was an increase in mean yield from 1,671 to 1,784 lb. per acre. But these responses were only just significant at the 5 per cent. level.

An interaction between the main plots and the manurial treatments was found. As in 1957, sulphate of ammonia gave a significant increase in yield only in the plots shaded with *Albizzia*. It appears that *Albizzia* does not supply all the nitrogenous requirements of coffee. In the *Grevillea* plots there was a significant decrease in yield to phosphate and an increase to potash.

The yields for 1960 are the actual yields of clean coffee harvested. High winds in January damaged bearing primaries; 5 per cent. of the total potential crop failed to mature and was harvested as mbuni.

It is a reflection on the management of the coffee that no cases had yet appeared of the dieback disease, *Fusarium stilboides*, which had attacked so much coffee in Nyasaland. In March, 1960, when the coffee was 6½ years in the field, twenty plants were found to be infected. There were three cases (0.02 per cent.) of "collar rot", probably due to damage when cultivating, and these trees were uprooted. There were seventeen cases (1.1 per cent.) of "scaly bark" in which the pathogen had entered through the pruning wounds. These plants were closely observed at frequent intervals; the sporulation behaviour and spread of mycelium in the coffee tissues were noted. All infected material was removed in June, 1960. Since that date all plants have been carefully examined at regular intervals and no further infection has yet been recorded. As the disease was recognized in its early stages, the removal and burning of all infected material appeared to have controlled the spread of the disease. The low percentage of infection has also shown that a healthy plant is less likely to be attacked by *Fusarium*.

A higher percentage of attacks was found in an adjacent trial in which the trees are two years younger and in which some trees were weakened by overbearing, particularly in one block where gully erosion had left a patch of poor soil. In this trial there was one case (0.01 per cent.) of collar rot and 29 cases (3.3 per cent.) of scaly bark. Here again the same measures were taken and no further attacks have been observed.

The trees in the shade/mulch/manurial experiment have now been converted to the second cycle. One bearing head had been removed in the previous year from trees in the guard rows but both stems were allowed to bear in the plots. Five suckers were allowed to arise from near the base of the trees and were later reduced to three. In September, 1960, when the trees were pruned, sucker growth was examined.

TABLE III
Sucker Production in Converted Multiple Stem Trees

		Average Number shoots per tree	Mean Height shoots (cm.)
Main Plots (two stems)	(1)	2.14	} 128.9
	S	2.16	
	SM	2.38	
	M	2.63	
Guard Rows (one stem)	—	2.80	145.2

2. FURTHER INVESTIGATIONS ON SHADE AND MULCH

TABLE IV
Shade/Mulch in Coffee, Gala
(Yield clean coffee, lb. per acre)

<i>Treatment</i>						1957	1958	1959	1960	<i>Mean</i> 1957-60
M	..	..	..	..	..	No Crop	2,834	No Crop	2,528	1,341
SM	..	..	..	..	..		2,766		1,432	1,050
(1)	..	..	..	..	..		2,811		2,492	1,326
S	..	..	..	..	..		2,587		891	895
Lowest Sig. Diff.	..	..	..	..	..	Not Sig.		—	—	—
Coeff. of Variation	..	..	..	..	..	No Crop	14.1%	No Crop	—	—

TABLE V
Effect of Albizzia as a Shade Tree
(Yield, clean coffee, lb. per acre)

	<i>Mulching Material</i>		
	<i>Napier</i>	<i>Sawdust</i>	<i>Mean</i>
<i>Albizzia</i> Shade	1,212	1,084	1,148
No Shade	924	1,053	989
Mean	1,068	1,068	—

The yield of clean coffee, the second crop to be harvested in this experiment, was significantly greater when shaded with *Albizzia* and mulched with napier (Table V). When sawdust was used as a mulch, it did not depress the yield although no additional nitrogen had been given.

The competition of the shade trees with the coffee for moisture available in the rooting-range of the coffee was also studied. Soil samples were taken to a depth of 8 feet, 1 foot deeper than last year. Soil moisture was determined; of this 23.22 inches are retained by the soil at wilting point. The balance, the amount of available water, is shown in Table VI.

TABLE VI
Inches Available Water Present to a Depth of Eight Feet, under Mulched Coffee, 1960

			July	September
S.M. <i>Albizzia</i> Shade	..	..	10.11	7.43
(1) <i>Grevillea</i> Shade	..	..	10.16	10.13
M No Shade	..	..	11.22	10.88

These results suggest that, although *Albizzia* reduces the available moisture more than *Grevillea* or no shade it does not necessarily follow that the crop will be reduced. The effect of shade upon the coffee crop is therefore not purely a result of soil moisture relations.

Observation plots of coffee have been established under mature A-type tung. The tung stands at three plant populations; it forms a closed canopy when the tree population is not reduced. In a closed canopy the coffee internodes are etiolated. The tung also competes with the coffee for moisture; it flowers and sets its fruits before the rains and under such conditions the coffee frequently wilts. The soil moisture status is being studied. In this trial coffee trees are being grown on the multiple stem system and a modified form of the single stem system.

3. OTHER MANURIAL TRIALS

At Bvumbwe a nitrogen fertilizer experiment was planted in December, 1959, using the fertilizers, sulphate of ammonia, calcium ammonium nitrate and urea, each at two levels. Details will be given when the trees come into bearing. At this stage it is only necessary to note the effect where high rates of fertilizer were applied, i.e. either 6 oz. sulphate of ammonia or C.A.N. per plant or 3 oz. urea per plant; the fertilizers were applied in bands around the trees in two split dressings. Within a week of applying the second dressing of fertilizer many plants wilted and the leaves were scorched around the margins. The most affected trees were those in the sulphate of ammonia plots in which seven vacancies occurred; there were two vacancies in the C.A.N. plots and none where urea was applied. This is being studied further.

At Katowo, manurial trials have hitherto yielded no results because the coffee was planted in an extremely exposed position. Now that bananas have been planted and fencing erected, the coffee is healthier and the trees are retaining their foliage. This year's crop did not reflect the previous manurial treatments but was more a measure of the amount of defoliation which occurred in the previous year which in turn varied with the degree of exposure. The treatments were scored on the appearance of the foliage. Mulched trees were better than those not mulched; the best trees were those which had received dung and mulch. In a manurial factorial a response could be seen to nitrogen. The response appeared to be greatest in the presence of phosphate.

At Mzuzu a 4×2×2 N.P.K. manurial factorial experiment was planted and established successfully. Two previous attempts had failed. Several factors were thought to be the cause of failure: zinc and iron deficiency, low pH, but, as was shown at Katowo, the main limiting factor was exposure. When a temporary windbreak of *Tephrosia* had been established and grass fencing erected, very satisfactory growth resulted. The experiment is shaded with *Grevillea*.

4. COFFEE SUN-HEDGE SYSTEM

The sun-hedge system is widely employed in Guatemala. Pruning is kept at the minimum, thus further reducing maintenance costs. Single and double row hedges are left entirely unpruned. Harvesting is greatly facilitated.

Object.—In Nyasaland study of the *Fusarium* dieback has shown that one of the main entry points of the pathogen is through pruning wounds. The sun-hedge system is therefore attractive as a possible means of reducing the entry points of the disease. Three observation plots were planted at Bvumbwe in December, 1959.

Treatments—

1. Two single rows 9 feet apart.
2. Two double rows at a spacing of 3 feet $\times$ 9 feet.
3. Two triple rows at a spacing of 3 feet $\times$ 3 feet $\times$ 9 feet.

In all rows the trees are 3 feet apart.

Varieties planted—

SL.6, SL.9, Ke20, Ordinary Bourbon, Mayagese Bourbon, Mibirizi, Blue Mountain, S.288.

All plots were successfully established. The trial will be reported further when the trees come into bearing.

2. Variety Trials

1. COLLECTION OF KENYA AND TANGANYIKA SELECTIONS

Site.—At Bvumbwe as for shade/mulch/manurial experiment.

Planting.—Planted in December, 1955, at a spacing of 9 feet $\times$ 9 feet.

Pruning system.—Multiple stem.

Object.—To compare the yields and general performance of twenty-seven seed selections from Lyamungu (Tanganyika) and Ruiru (Kenya) with a local selection from the Southern Province of Nyasaland.

LAYOUT.—Randomized block with eight replicates. Three plants per plot.

Varieties.—From Tanganyika: H.66, H.133, I.60, KP.128, KP.162, KP.228, KP.423, L.1, N.5, N.39, N.81, N.197.

From Kenya: Ke20, K.S.A. (Kapretwa Series A), K.7, Kent's Hybrid, SL.6, SL.14, SL.28, SL.34, Blue Mountain, Mocha, Geisha, Dalle Mixed, Maragopipe, Dilla and Alghe.

After the 1959 crop each variety was pruned to a head of not more than three feet. In some cases, where the trees were in a state of poor vigour, a smaller head was allowed.

TABLE VII
Coffee Variety Trial, Bvumbwe, 1960
(Yield, clean coffee, lb. per acre)

<i>Variety</i>	<i>Yield</i>	<i>Variety</i>	<i>Yield</i>
SL.28	1,711	SL.6	989
SL.34	1,519	K.S.A.	989
KP.162	1,426	H.66	969
Kent's	1,329	KP.228	949
SL.14	1,276	I.60	941
KP.423	1,269	Ke.20	922
Blue Mountain	1,135	KP.128	914
K.7	1,126	Maragogipe	889
Local	1,116	Mocha	878
N.197	1,104	Dalle Mixed	853
Dilla and Alghe	1,099	N.5	845
Geisha	1,048	N.81	800
N.39	1,018	L.1	739
H.133	993		
		Mean	1,068

Least Significant Difference: P=0.05 395
P=0.01 519
Coefficient of Variation 37.7%

In spite of heavy winds damaging the trees, the mean yield of this experiment, 1,068 lb. clean coffee per acre harvested, was only slightly less than that harvested in 1959 (1,168 lb.).

The Kenya selections SL.28, SL.34 and SL.14 and the Tanganyika selected KP.162 have been the best yielders for the two years recorded. Certain varieties, N.81 and KP.128 and H.66 which overbore last year, have borne reduced yields this year showing a slight biennial bearing tendency. This has been observed before at Bvumbwe with H.66. It appeared that conditions were not suitable for Blue Mountain, Geisha, I.60 and K.S.A. which developed more mbuni than any other variety.

2. OBSERVATION PLOT OF TANGANYIKA SELECTIONS

Plots of Tanganyika selections were planted in the guard rows of the shade/mulch/manurial experiment at Bvumbwe in 1953. A complete cycle of four years cropping has been harvested.

TABLE VIII
Observation Plots of Tanganyika Selections, Bvumbwe
(Yield, clean coffee, lb. per acre)

<i>Variety</i>	1960	<i>Mean</i> 1957-60
N.81	1,327	1,483
N.197	860	1,261
N.39	1,257	1,140
Brazil	587	1,042
L.1	683	955
H.66	778	890
N.5	1,013	729
KP.423	868	721
KP.162	848	718

The varieties N.39, N.81, N.197 and Brazil have remained consistently the best in these selections. The plots are not planted in a statistical design and the results can only be taken as an indication until formal variety trials have yielded further information.

3. COLLECTION OF KENYA VARIETIES

Site.—at Gala 3,500 feet altitude on the Limbe-Zomba road in a drier climatic area than Bvumbwe. Soil is a shallow, sandy clay loam overlying weathered sandstone and quartz.

Planting.—Planted in December, 1956, at a spacing of 9 feet $\times$ 9 feet.

Pruning system.—Multiple stem.

Object.—To compare the yields of five seed selections from Kenya with one imported from Brazil.

Layout.—Randomized block with six replicates. Ten plants per plot.

Varieties.—Blue Mountain, SL.14, SL.28, SL.34 and Columnaris from Kenya. The selection from Brazil is an unnamed Bourbon type.

Results.—The yields, see Table IX, show that the three Scott Laboratory selections from Kenya can be expected to produce well over 7 cwt. of clean coffee per acre. SL.28 and SL.14 yielded significantly greater than the Brazilian selection or Blue Mountain.

TABLE IX
Coffee Variety Trial, Gala, 1960
(Yield, clean coffee, lb. per acre)

Variety						Yield
SL.28	..	..	..	..	..	1,283
SL.14	..	..	..	..	..	1,198
SL.34	..	..	..	..	..	1,116
Brazil	..	..	..	..	..	862
Blue Mountain	..	..	..	..	..	733
Columnaris	..	..	..	..	..	85
Low Sig. Diff. $P=0.05$	..	..	..	..	..	266
$P=0.01$	..	..	..	..	..	360

Columnaris, although it grew very vigorously, failed to develop flower buds. The yield recorded came from some off-type and rogue trees. No flower buds have been developed again in 1960. This selection is noted in Kenya for its shy-bearing tendency, especially at high altitudes; it was thought that this characteristic may be of value in areas where forcing growth and over-bearing would be a serious disadvantage in most other types. *Columnaris* was included in this variety trial for this reason.

4. VARIETY TRIAL, BVUMBWE

A further selection of varieties from the former Belgian Congo, Kenya and India was planted at Bvumbwe in December, 1959, in a randomized block design. They were:

from INEAC: Rubona, Congo: Kent's, Blue Mountain (Jamaica), Ordinary Bourbon, Mibirizi, Mayagese Bourbon and Jackson.

from Ruiru, Kenya: SL.9, SL.28, Blue Mountain, Kenya Selected Clone 33, Rume Sudan and Columnaris.

from Balehonnur, India: S.288 (Mysore).

All selections established satisfactorily except plants of Blue Mountain, Jamaica, which succumbed after a dry spell at the end of January, 1960.

5. VARIETIES AND PRUNING

In a variety and pruning trial at Bvumbwe, in which fuller details will be given in a later report, one treatment was to allow the trees, which are pruned on a multiple stem system, to bear as soon as they flowered. The flowers are normally stripped until the third year from planting. The coffee was planted in December, 1957. *Kenya Selected* grew rapidly and proved to be a precocious variety; it bore its first crop in 1959. All four varieties bore a small crop in 1960. There was no significant difference between the yields.

TABLE X
Early Bearing of Coffee, Bvumbwe
(lb. clean coffee per acre)

Variety				1959	Yield 1960
Kenya Selected	..	..		38	870
SL.28	..	..		—	734
SL.14	..	..		—	659
Kent's Hybrid	..	..		10	635

Trees which were allowed to bear early developed leaf chlorosis symptomatic of nitrogen deficiency and some defoliation occurred.

6. VARIETY MICROPLOT TRIALS

Object.—The purpose of these plots is to demarcate the areas in which coffee would be a suitable crop and to indicate the varieties suited to those areas.

Sites and Soil Type.—Sites have been chosen all over Nyasaland by district officers with specialized knowledge of the locality, in which rainfall was considered adequate, temperature not excessive and soil of good depth. Most of the areas chosen have a mean annual precipitation of not less than 50 inches per year, 3 to 5 inches of this falling during the dry months May to October. The temperature is largely determined by altitude. Plots have been divided for this purpose into three categories: low, medium and high altitude. In Northern Province a low altitude plot would be at or below 4,000 feet, and a high altitude above 5,000 feet; in the Southern Province the divisions would be at 500 feet lower. The maximum temperature reaches high levels in the two months, October–November, preceding the rains. It commonly exceeds 70°F and at the low altitude sites exceeds 90°F. Such hot conditions force the coffee into early extension growth and place the trees under very heavy moisture stress. With the object of assisting the coffee to command as much available water as possible, sites with deep soils are selected and examination pits 10 feet deep are dug to ensure that there is no impeding layer. Soils of a high moisture retention capacity are chosen although their origins and hence their chemical compositions may be very diverse.

Layout.—5 × 5 latin squares with one tree per plot. The whole is surrounded by one guard row making 49 trees in all.

Treatments.—Five varieties in the latin square. - Those most likely to do well in the area are chosen. Four other varieties are planted in the guard rows. One variety, SL.28, is planted in all plots.

Twenty-six plots were planted in 1958/59. These were unshaded. Fourteen more were planted in 1959/60 alongside the first plantings or elsewhere and were shaded, usually by *Grevillea* or *Albizia*, which were planted at the same time.

The following seed selections were represented:

In the 1958/59 plantings.

From Tanganyika: .. H.66, KP.162, KP.228, KP.423, L.1, N.5, N.39, N.81, N.197.

From Kenya: .. SL.14, SL.19, SL.28, SL.34, K.7, Dalle Mixed.

From Brazil: .. an unnamed selection.

In the 1959/60 plantings.

From Kenya: .. SL.6, SL.9, SL.14, SL.19, SL.28, SL.34, K.7, Ke20, Kenya Selected Clone 33, Rume Sudan, Blue Mountain, Kent's and Columnaris.

From India: .. S.288.

From Nyasaland: .. a local selection from Northern Province which is of variable origin.

All plots were mulched and sheltered where necessary with windbreak trees or fencing if the natural windbreak was inadequate. In some cases, individual shelters were constructed for the plants until they had become established.

All plants on both occasions were of the same age and were grown in the same nursery at Bvumbwe. They were distributed by air and were packed bare root in polythene sleeving.

Results.—During the period of establishment and before cropping, records are being maintained of the growth of the trees in the plots. The number of vacancies, height and chlorosis counts are recorded.

At this stage it is premature to suggest that any variety will do better than the local which contains not only selections from Southern Province and from *Kent's* but also selections brought over the border in small quantities from Tanganyika. The green-leaved Bourbon types N.197 and *Brazil* established and grew best in the 1958/59 plantings. On plots which have suffered extreme fluctuations of temperature, usually exposed sites, they have suffered severely, the leaves have become very chlorotic and in the worst cases the trees have defoliated. *Dalle Mixed* has established and grown outstandingly well wherever it was planted and the SL. (Scott Laboratory) selections from Kenya seem little affected by forcing conditions where they have survived transplanting.

Plants in the 1959/60 plots did not establish as well as in the first. Rainfall was not so well distributed and in many cases the coffee had to pass through a dry spell soon after planting. The local selection, although it came from nearby nurseries, was not outstanding.

In Central and Southern Provinces, Cholo District has the most promising localities for coffee. Throughout the coffee areas brown eye spot disease, *Cercospora coffeicola* caused serious defoliation in 1960. Some losses resulted from these attacks. Where the plots were exposed to the wind, necrosis of the young foliage and growing tips occurred. This was a general problem but was particularly noticeable in the Misuku in Northern Province.

The best plots were generally those at the medium altitudes where the rainfall was adequate and temperatures not too high. Two outstanding plots, one in Southern Province at a low altitude and another in Central Province at a high altitude, were evidently planted in well-chosen sites.

7. COFFEE LIQUORING TESTS

Samples of the most promising varieties of coffee have been sent to Coffee Liquorers in Kenya and Tanganyika since 1957.

In all varieties it was noted at first that many insect damaged beans occurred. Their frequency was much reduced when *Antestia* was controlled. The size of the bean was smaller in 1960 than in previous years. This was because the crop had suffered from drought. The raw coffee was often heavily coated with silverskin and light in weight. The roast was often soft and open.

SL.34 produced an undesirable type of bean which was long and thin, being a Harrar type. These characters are typical of a climate which induces fast growth and early maturing. In 1959 when climatic conditions were less adverse, SL.34 produced the best sample. N.197 and SL.28 produced the best samples over the years. But when *Dalle Mixed* was included in 1960, it produced the most attractive all-round sample. The bean is a nice shape, roast fairly bright with attractive centre-cut and the liquor with fair to good acidity and fair body. This variety, although not a heavy yielder at Bvumbwe, has established well in the microplot trials.

The assistance rendered by Mr. C. R. Devonshire of the Liquoring Department, Kenya Coffee Marketing Board, and by Mr. W. R. Forder, Liquorer to the Coffee Board of Tanganyika, is gratefully acknowledged.

3. Age of Planting Material

Object.—The experiment has two main objects:

- (1) to assess the chances of survival of plants at 12 months and 18 months of age and planted with bare roots or balled-roots,
- (2) to determine whether 18 month old plants can be expected to bear a crop before 12 month old plants.

The experiment was planted at Bvumbwe in December, 1958. It was described, with the results of the first phase, in last year's report.

TABLE XI
Growth of "Age of Planting Material" after 18 months

Treatment					Mean Height (cm.)
Balled Roots, 15-18 months	..	..	..	..	104.1
Bare Roots, 15-18 months	..	..	..	..	88.2
Balled Roots, 12 months	..	..	..	..	86.0
Bare Roots, 12 months	..	..	..	..	81.5
Least Sig. Diff. $p=0.01$	..	..	..	..	16.1
Coeff. of Variation	..	..	..	..	9.4%

Growth was measured 18 months after planting. At this stage, the balled root, 15-18 month old plants still maintain their superiority and are significantly larger in size. The balled root, 12-month-old plants have almost caught up with the 15-18 month bare-root plants.

4. Irrigation of Coffee, Bvumbwe

Object.—To assess the effect of irrigation at various times of the year in relation to different stages of growth and of the crop.

Site.—Tanganyika selections planted in 1953 and grown on the multiple stem system.

Layout.—Randomized block with three replicates eight trees per plot.

Treatments.—1. Control. No irrigation,
2. Irrigate maturing crop only,
3. Irrigate during flowering period only,
4. Combination of 2 and 3,
5. Irrigate monthly as required.

Soil samples are taken regularly to calculate the amount of water to be applied. The available soil moisture is not allowed to fall below three quarters field capacity. The calculated amount of water per acre required to restore soil moisture at three quarters field capacity is applied to the trees through basins 4 feet square in size. The experiment commenced at the end of the rains, April, 1959. The first crop to be affected was that harvested in June/August, 1960.

TABLE XII
Irrigated Coffee, Bvumbwe, 1960

<i>Treatment</i>	<i>Mean Yield Cherry, kgm. per tree</i>	<i>Irrigation Time</i>
1 Nil	3.00	—
2 Maturing Crop	4.47	June
3 Flowering	4.53	September and October
4 Maturing and Flowering	5.54	June, September and October
5 Monthly	5.65	September, October, November and June
Lowest Sig. Diff. $p=0.05$	1.67	
Coeff. of Variation	19.1%	

Significantly greater yields were given by the two highest rates of irrigation.

5. Coffee Physiology

In Nyasaland various factors, exposure, soil acidity, moisture, temperature, limit the normal growth of coffee. These factors interact and a change in any one of them may result in unsatisfactory development of the tree. The limiting factor varies with the locality but exposure is the most widespread. Chlorosis of the leaf symptomatic of zinc and potash deficiencies result. These symptoms were described in the 1957/58 report (p. 115) and, from the evidence available, they appeared only where coffee was grown in an exposed site.

Young unshaded coffee planted at Bvumbwe in 1959 developed symptoms of chlorosis in June. Six of the trees were surrounded in September with old cement drums cut to within 6 inches of the height of the trees. Complete shelter was provided. Within two weeks foliage assumed a deeper hue and signs of chlorosis disappeared except in the older leaves where necrotic patches had developed. It appeared that shelter had prevented extreme fluctuations of temperature but the whole field recovered soon afterwards at a time when the diurnal range of temperature was greatest (see Table XIII). Wind velocity was lowest during August and September and protection from wind and therefore reduction in transpiration losses may be a more important factor.

TABLE XIII
The Range of Temperature and Wind Velocity
Bvumbwe, May to August

Month	Week	Mean Temperature °F		Diff.	Daily Mean Wind Speed (knots)
		Maximum	Minimum		
May	1	73.0	58.2	14.8	5.8
	2	73.1	56.3	16.8	2.3
	3	71.6	56.5	15.1	6.4
	4	70.0	54.9	15.1	5.2
June	1	68.1	55.8	12.3	5.3
	2	66.7	53.3	13.4	6.2
	3	63.3	52.0	11.3	3.6
	4	63.6	51.4	12.2	6.1
July	1	64.5	53.3	11.2	6.8
	2	64.1	51.2	12.9	4.2
	3	65.3	49.0	16.3	4.8
	4	62.6	47.9	14.7	6.4
August	1	62.0	54.4	7.6	3.3
	2	59.5	49.3	10.2	4.1
	3	68.4	52.9	15.5	4.6
	4	68.3	52.0	16.3	4.1
September	1	74.4	57.1	17.3	2.9
	2	80.7	58.3	22.4	4.9
	3	80.9	59.2	21.7	4.8
	4	84.0	60.8	23.2	6.1

Extension growth was studied over the period of one year.

Object.—To determine at Bvumbwe the period in which maximum extension growth occurred so that a single application of a fungicidal spray would provide maximum protection.

Method.—Ten trees of the Kenya Selection SL.28, which is well suited to the area, were selected and divided into two groups. In five trees young primaries, one in each direction North, South, East and West and a growing tip were selected and labelled. This was repeated in the second group. The number of internodes and length of the shoot were measured weekly for a period of one year.

TABLE XIV
Extension Growth of Coffee

Month	Mean length shoots, cm.	Increment cm.	Mean No. of nodes	Increment	Length of Internodes cm.
April, 1959	43.2	1.3	19.2	0.8	1.6
May	43.6	0.4	19.6	0.4	1.0
June	44.0	0.4	20.0	0.4	1.0
July	44.0	Nil	20.0	Nil	—
August	46.6	2.6	22.0	2.0	1.3
September	48.6	2.0	24.8	2.8	0.7
October	50.8	2.2	26.4	1.6	1.4
November	57.6	6.8	31.0	4.6	1.5
December	58.8	1.2	31.5	0.5	2.4
January, 1960	60.0	1.2	32.5	1.0	1.2
February	63.8	3.8	34.9	2.4	1.6
March	64.3	0.5	35.4	0.5	1.0

Most extension growth was made in the hot spell before the rains and not during the rains. The length of the internodes, which is found by dividing column 2 by column 4, was not constant but was greatest in December at the beginning of the rains. The rate slowed down as soon as flowering commenced. There was a second flush of growth in February when the cherry had set and was still small. Thus a protective spray in December would cover most of the foliage produced. Another early in March would cover any growth made subsequently.

6. Cost of Coffee Production

Object.—The Mixed Farm Unit has a small coffee unit attached to it so that the cost of coffee production under ordinary commercial conditions can be estimated.

Site.—The site is a field which had been under napier grass (*Pennisetum purpureum*) for coffee mulch for five years.

Soil.—The soil is typical of that described for Bvumbwe. There is a layer of quartz 6 inches thick at a depth of from 6 to 7 feet but it is not impenetrable. The field is 5 acres in size. It is protected from the wind by pines (*P. patula*) and bananas planted along the boundary.

Ten rows of coffee were planted to alternate with an equivalent strip of mulching grass. The grasses planted are Gold Coast Napier and *Echinochloa pyramidalis*. The napier was planted at 6 feet $\times$ 3 feet spacing and the *Echinochloa* at 3 feet $\times$ 18 inches.

The coffee was planted at a spacing of 10 feet 6 inches $\times$ 7 feet 6 inches (553 trees per acre) so that it could be cultivated by tractor. There are three acres of coffee. Half of the coffee can be mulched with the grass adjacent to it. The other half is mulched with maize stover transported from the farm.

TABLE XV

Cost of Establishing a Small Coffee Plantation, 1st May, 1959 to 30th June, 1960

	Total Cost five acres			Per acre of Coffee ($\div 3$)		
	£	s	d	£	s	d
To						
Ploughing, Cultivating and Bunding	15	16	1	5	5	4
Surveying, Pitting, Manuring and Filling-in	39	8	1	13	2	8
Planting Coffee	13	4	8	4	8	3
Planting Napier and Windbreak	8	17	9	2	19	3
Cost of Plants (Estimated: 1,700 at 6d)	42	10	0	14	3	4
Weeding, Hand and Mechanical	38	1	3	12	13	9
Carting and applying Maize stover	39	5	7	13	1	11
Fertilizer	5	3	9	1	14	7
TOTALS	£202	7	2	£67	9	1

Table XV shows the actual costs incurred which do not include an element for overheads. The cost of ploughing out the napier is included.

It has therefore cost £67 to establish an acre of coffee and two thirds of the supporting mulching material. The napier supplied no material this season and all the mulch had to be carted from the farm. Maize stover was accumulated in 1959 prior to planting; it was augmented in February with some silage residue and in June with maize stover from the 1960 crop. The total cost of collecting the stover is not included but is estimated at a further £20. Thus mulching with material which has

to be cut and carted from another field is a costly item to appear in the recurrent expenditure. Next year, when the napier is bearing, less stover will be required and it should be possible to reduce this cost.

No pest or disease control has yet been necessary and this item will appear in future recurrent costs.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

MICRO NUTRIENTS

With the better selection of sites, the incidence of zinc deficiency has decreased.

One isolated instance of iron deficiency symptoms was observed, the leaf content being 40 p.p.m. compared with a general level of 80–200 p.p.m. found in leaf throughout the territory. As 40 p.p.m. is within the normal range reported from some parts of the world, it is possible that the effect was exaggerated by the abnormally dry conditions, which also produced several instances of necrosis which looked like potash deficiency, but this was not confirmed by analysis.

SOIL ACIDITY

Reports from several localities indicated that small bushes had died following the application of ammonium sulphate, or in some instances of cattle manure. Examination of soil samples from affected and good bushes, did not show a consistent difference in pH, although an immediate localized effect on the roots would not be reflected in soil samples taken when the bush eventually died. Subsequent information did show that in some instances excessive fertilizer had been applied—but as this phenomena has been reported also with cattle manure and C.A.N., a fuller examination by pot tests and field trials is being made.

Although soils of pH 6–7 are desirable for coffee, especially since this may improve their resistance to *Fusarium*, it may not be practicable to obtain these in the areas of satisfactory rainfall for coffee, this being accentuated by the one rainy season. The occurrence of good coffee on soils of pH 5.5 or less has demonstrated that contributory factors of shelter may be of equal importance.

MULCHING

Various mulching materials used for coffee were examined with particular reference to their K and Mg contents, in relation to reports of K induced Mg deficiency in East Africa.

			<i>Napier Grass</i>	<i>Echinochloa Pyramidalis</i>	<i>Tung Hulls</i>	<i>Coffee Pulp</i>	<i>Coffee Hulls</i>
K	..	..	4.4	0.9	3.4	4.2	0.42
Mg	..	..	0.45	0.45	0.59	0.15	0.02

This data must also be considered against the composition of the soil on which the mulch is applied, the desirable Mg/K ratio of $>3/1$, generally being met in local soils. The slower rate of decomposition of tung hulls, although of higher K content, must also be considered.

SULPHUR IN COFFEE

Arising from the possibility of sulphur deficiency in coffee being a contributory factor in the incidence of *Fusarium*, figures previously determined on coffee from affected and non-affected leaf, were reinforced by examination of leaf from the

experimental plots at Bvumbwe, where ammonium sulphate had been used. Thus if there was a tendency to deficiency, it would be expected that leaf from the fertilized plots would contain appreciably more sulphur.

Leaf from control plots contained 450 and 310 p.p.m. sulphur, and those from plots receiving sulphur in sulphate of ammonia contained 360 and 330 p.p.m. sulphur. These figures showed little difference, and are in fact slightly less than figures of 800–1,000 p.p.m. found in coffee in the Northern Province and in some Cholo estates. Published data for total sulphur in coffee give figures of 600–1,000 p.p.m. and in tea the level has been found to be 300–400 p.p.m. in satisfactory leaf. Tea leaves showing yellows have only contained one tenth of this amount, i.e. about 30 p.p.m. S.

A secondary aspect of this was the possible explanation of slow growth of coffee, treated with tung cake, as due to sulphur shortage. The sulphur content of tung cake is admittedly fairly low, various samples examined containing from 300 to 600 p.p.m. but it is more probable that the slower release of N from the cake is effective. Where these effects were noticed, there was a shelter/shade factor which might have been important—thus the coffee with S/A was under tung shade, but that with tung cake was more in the open.

It is proposed to check whether S was the important factor by equating the sulphur to that applied as S/A. Thus for every 4 oz. of S/A applied, 5 oz. gypsum is added to the tung cake applied.

Extract from Report of the Plant Pathologist

Armillaria mellea (Fr.) Quel, was confirmed on coffee for the first time this year. This was in a garden where most of the *Allizzia* shade trees have been killed by the fungus. Despite this record, coffee can still be considered resistant to *A. mellea* in Nyasaland conditions.

Fructifications of the fungus were produced, but they apparently only last for a very brief period which may account for previous observations that *A. mellea* does not commonly produce fructifications in Nyasaland.

The *Fusarium* bark diseases are widespread and are still causing much destruction. A separate report covers an investigation into the diseases.

The *Stem Pitting* condition of coffee was found to be very severe in August in a field of variety KP. 532 planted in November, 1958. Marked pitting of the stem was noted and a marginal chlorosis and distortion of the young leaves, which had necrotic tips, appeared to be associated with it. The older leaves were markedly reflexed on the laterals, hanging down with the tips twisted back towards the main stem.

Extract from Report of the Entomologist

Leucoptera coffeina Washbourn, a Coffee Leaf-miner, occurred in February and March. Although widespread in the country, severe damage was very local and confined to a few bushes in each place. Such bushes were normally strongly shaded and the pest is only normally severe under such conditions. One fluid ounce Diazinon in 4 gallons water with a second spray 10 days later has been found to give adequate control.

Antestiopsis variegata Thunb., the Cameroon Bug, occurred as usual, being most numerous on new plantings coming into bearing. D.D.T. and Malathion give control, but tests with Pyrethrum and Sevin are being made. D.D.T. is advised at present.

Habrochila sp., a Coffee Tingid-bug or Lace-bug, was recorded in some numbers at Bvumbwe in October. Malathion has been recommended at 2 fluid ounces per 4 gallons water in two applications at 15 days interval.

A number of species of fruit-flies have given trouble this season. Two of these have been identified as *Trirhithrum nigerrimum* Bezzi and *Zaprionus vittiger* Coq. by the Commonwealth Institute of Entomology. A sodium fluosilicate or Malathion bait-spray was recommended. These fruit-flies attack the ripening cherry and the larvae feed in the pulp, often discolouring the parchment of the bean. They have a number of alternate hosts.

Annual Report of the Fusarium Scheme Pathologist

In the course of the year all coffee growing areas in the country were visited. *Fusarium* bark disease in one of its three forms, viz. Storey's bark disease, Scaly bark and Collar rot, was found in all areas, and frequently all three forms were found in one area. The disease occurs most commonly in the presence of debilitating factors. Exposure, overbearing, and pest attack all contribute to make the plants more liable to disease. In one area, the first symptoms were noticed in a field at flowering time, a period of physiological stress. No evidence has yet been found to contradict earlier expressions that this fungus is a wound pathogen and is only able to colonize coffee plants made weak or unthrifty for any reason.

Nine species of *Fusarium* have been isolated from diseased wood and soil. Only one of these, *Fusarium lateritium* Nees ex Fr. var. *longum* Wollenw (*F. stilboides* Wr. forma) has been consistently isolated from all three forms of the disease. Its identity as causal agent has been confirmed by inoculation tests. An inoculation experiment designed to find out if one of the three forms of the disease, Storey's bark disease, can be caused by inoculation with the fungus isolated from all three phases has been started and is intended to go on for a year, making inoculations at different times of the year. Final results will not be available until next year, but the first series of inoculations have shown that Storey's bark disease can be successfully induced by inoculation with *F. stilboides* from the Collar rot and the Scaly bark forms of the disease. Representative isolations were confirmed by Dr. W. L. Gordon of Canada.

OBSERVATIONS ON THE COURSE OF THE DISEASE

Spore production: Spore production is discontinuous. It appears to be related very closely to warm, humid conditions, and is most profuse during the period January-March when temperatures and humidity are high. During the cooler dry months May-September, production of spores is reduced considerably, but showers of out of season rainfall can cause a slight increase of production during this period.

Spore dispersal: Spores are easily dislodged from sporodochia when they are wet. Spores have also been isolated from rain and dew drops on leaves in infected fields. It would thus appear that water is the primary agent of spread, the fungus being raindrop-splash borne in the first instance. *Fusarium* spores appearing on slides in a spore trap over a short period have been cultured and identified as *Fusarium solani* and *F. equiseti*. *F. stilboides* has not yet been found on spore trap slides, but this cannot be taken as an indication that the fungus is not wind borne, as too few slides have been sampled this way. Spores of *F. stilboides* have been isolated from the outer integument of insects (*Antestiopsis* sp.). Whether this common pest of coffee in Nyasaland is implicated in spread of the disease is a moot point, and requires further investigation.

Entry of the fungus: Observations indicate that entry of the fungus is entirely through wounds. Inoculations done without wounding are invariably unsuccessful. Pruning wounds, fresh leaf scars, dead and rotten bark tissue and wounds incurred during cultivation are implicated. Entry appears to take place during periods of high temperature accompanied by prolonged wet conditions. Collar rot has been shown to be associated with planting of seedlings too deeply. This causes necrosis and rotting of the outer bark tissues between the nursery soil level and the soil level in the field affording a path of entry to the fungus. Mulching right up to the stem creates similar conditions for entry of the fungus.

Course of the disease: So far this has only been followed in Storey's bark disease. Wound inoculation of the fungus at the base of young suckers was carried out in the field. A yellowing of inoculated tissue started occurring 46 days after inoculation, and the symptoms progressed until 62 days after inoculation browning of the inoculated tissues was seen, and a slight constriction developed at the base of the sucker. In 91 days spore production had started.

Control: In the past a copper based fungicidal paste has been used to protect pruning wounds, which are an important point of entry of the fungus. The efficacy of copper fungicides, Captan (N-(trichloromethylthio)-4-cyclohexene-*a* 2-dicarboximide) and Thiram (tetramethyl thiuram disulphide) were tested in spore germination studies. The fungicides were at the rates recommended by the respective manufacturers. At 25°C Perenox gave no inhibition of germination, Bordeaux mixture 50 per cent., Thiram 93.7 per cent. and Captan, 100 per cent. Further tests were carried out using the copper based paste recommended in the past. Both in the laboratory and in the field, spore germination and entry of the fungus took place successfully on fresh pruning wounds under this paste. A new paste was made up using Captan, tung oil and paraffin wax. Complete inhibition of spore germination and protection of the wounded surface occurred with this paste. It is undergoing further field tests before being generally recommended.

A number of fungicidal trials are being carried out: results are only available for a preliminary trial using Captan. Copper fungicides were discarded early as a result of the laboratory tests described above and also a fungicidal trial started before the scheme came into operation. In the preliminary trial two rows of nine trees each were selected in an infected field, with guard rows round them. The trees selected were cut back in order to produce suckers, and one row of nine trees was sprayed with Captan at 2 lb./100 gallons twice a week during March, 1960, and the other row was unsprayed. At the start of spraying, suckers were 2-3 weeks old, and conditions during the month were ideal for spread of the disease. The results, presented below, show great promise in the use of Captan.

Sprayed	{	Total number of suckers—sprayed plot	..	49
		Suckers showing disease symptoms at start of experiment ..	..	14
		Suckers showing disease symptoms at end of experiment ..	..	14
Unsprayed	{	Total number of suckers—control	..	43
		Suckers showing disease symptoms at start of experiment ..	..	8
		Suckers showing disease symptoms at end of experiment ..	..	24

Captan protected all suckers not showing symptoms before the start of the experiment, but exerted no curative effect on those already infected. In the unsprayed control plot, the disease increased by 200 per cent.

Further trials are under way to determine the correct timing and concentrations of Captan sprays.

One danger that has been demonstrated by the studies reported above is the possibility that copper sprays may aid in dissemination of the disease. Coppers, particularly fixed coppers like cuprous oxide, have no inhibitory effect on the fungus, and do not protect surfaces to which they are applied. Water has been shown to play an important part in the dispersal of the fungus. It is quite within the realms of possibility, therefore, that a high volume copper spray, such as a tonic copper spray, if applied during the rains, will spread the disease and not control it.

The most satisfactory means of control for a disease of this nature is the growing of a resistant variety. So far varieties KP.162, H.66 and Ke20 have not been found with the disease in any of the many variety trials in the country. Further investigation will have to be carried out, however, before these can be recommended as resistant varieties in the badly stricken areas.

FRUIT AND VEGETABLES

1. Banana Manurial Trial

Bananas are grown commercially in the Cholo District and as a source of mulching material in the coffee areas. A $3 \times 3 \times 2$ N.K.P. banana manurial factorial was planted at Bvumbwe in the rains of 1958/59 with the local variety Kabuthu, a dwarf Canary type.

The treatments are:

N_0, N_1, N_2 —Sulphate of ammonia at 0, $\frac{1}{2}$ and 1 lb. per plant,
 K_0, K_1, K_2 —Muriate of potash at 0, $\frac{1}{2}$ and 1 lb. per plant,
 P_0, P_1 —Single superphosphate at 0 and $\frac{1}{2}$ lb. per plant.

The fertilizer dressings were split in two applications, December and January.

The spacing was 9 feet $\times$ 12 feet, giving 400 plants to the acre. No flowers were allowed to develop until February, 1960.

In the year before fruiting, there was a marked difference in growth between the plots. The foliage of those which had not received nitrogen was markedly more chlorotic. The rate of sucker production varied significantly with the nitrogen application (see Table I below).

TABLE I
Banana Manurial Trial

Treatment								Number of suckers per plant	Weight of Fruit 6/9/60 to 11/11/60 lb. per acre
N_0	..	..	..	..	..	..	..	6.0	2,946
N_1	..	..	..	..	..	..	..	7.6	4,506
N_2	..	..	..	..	..	..	..	8.2	5,585
L.S.D.	$P=0.05$	..	..	..	..	..	..	2.0	2,999

The first crop was harvested in 1960 and up to the time of writing this report, when there was still a proportion of crop to harvest, a response was obtained again only from nitrogen but this was not significant.

2. Pineapple Variety/Manurial Trial

The experiment at Bvumbwe bore its first ratoon crop in 1959/60.

Layout. —Two 3×3 latin squares with double rows 20 inches apart at 5 feet between centres. Plots of two double rows.

Varieties.—1. Smooth Cayenne or Kew Pine at 18 inches apart
 2. Hawaiian Queen at 12 inches apart
 3. Local Queen at 12 inches apart.

Fertilizers.—Sulphate of ammonia at 600 lb. per acre in two split dressings, December and May. To this treatment was added muriate of potash at 150 lb./acre in July.

TABLE II
Pineapples, 1959/60
(Yield, Short Tons per acre)

Variety					No Fertilizer	Fertilizer	Mean	L.S.D.
								(varieties) P=0.05
Smooth Cayenne	..	..	..	..	5.82	13.86	9.76	1.88
Hawaiian Queen	..	..	..	..	5.30	8.51	6.90	P=0.01
Local Queen	..	..	..	..	1.87	2.27	2.07	4.34
Mean	..	..	..	..	4.33	8.21		

L.S.D., P=0.05 3.67
(fertilizers) P=0.01 5.57
Coeff. of Variation 50%

Smooth Cayenne continued to be the best variety with a mean yield per acre of about the same as last year. There was a response to fertilizer similar to that obtained last year.

3. Deciduous Fruit

Observations are most advanced at Mwera Hill (4,800 feet) where the greatest selection of varieties is held. The climate is more suitable, winters colder and rainfall not excessive, than at other stations in Nyasaland. Winter chilling is the most important factor. Buds, particularly of deciduous fruits, require a certain minimal level of winter chilling before they are able to unfold. The chilling requirements of varieties vary and, if they are not satisfied, symptoms of prolonged dormancy appear. The altitude at Mwera Hill is not high enough to satisfy the requirements of some varieties which then have to be selected out as unsuitable for Nyasaland.

The dormancy of buds, which are insufficiently chilled, is prolonged over an indefinite period. Foliation is delayed too long after flowering and the young fruit cannot develop. Leaf buds may fail to open altogether and are shed. Flower buds may be damaged by high winter temperatures. The flowers may be shed as the bud unfolds or certain organs may be damaged; the pistils are frequently damaged in apple flowers which, as a result, produce seedless or malformed fruits.

The following varieties of deciduous fruits have proved unsuitable for the Nyasaland climate:

Almonds. All varieties tried, i.e. *Britz*, *Paper Shell* and *Jordan*.

Apple. *Cox's Orange Pippin*.

Apricot. *Royal*.

Peach. *Van Riebeeck*, *Oklahoma*, *Florida Crawford*, *Elberta*, *Boland*, *Brook* and all Clingstone types.

Pear. *Le Conte*.

Plums. *Burbank*, *Wickson*.

Soft fruits, youngberries and raspberries, and grapes (*Red Muscadel* and *Alphonse Laval*) are also unsuited to this climate. Grapes need shelter from the rain and very good growth is being obtained from vines planted against an office wall and protected by the roof overhang.

Figs similarly need shelter from heavy rain and have grown well when protected. The leaves are attacked by a rust which defoliates the trees. The young shoots are attacked by a stem boring beetle, the adult of which ringbarks and kills them.

In an orchard in which many types of fruit are grown, the control of fruit fly has presented a problem. Poison sprays baited with a protein extract from a sauce factory and with fruit juice concentrates were not as effective as a sugar bait. Malathion was used as the insecticide. The incidence of attacks increased as soon as the rains commenced. Guavas, which fruited towards the end of the rains, were most severely attacked. Frequent sprayings on this low-value crop would prove uneconomic.

4. Tomatoes. Time of Planting

Object.—To determine at what period towards the end of the rains tomatoes could best be grown. The puree variety *San Marzano* was used.

Observation plots, 25 square yards in size, were planted monthly at Bvumbwe at a spacing of 3 feet $\times$ 18 inches for four succeeding months commencing in mid-February. Seed was sown in individual pots and seedlings were ready for planting a month after sowing.

Plots were previously manured overall with dung at 15 tons per acre. After planting a 6:6:6 mixture at 200 lb. per acre was applied.

TABLE III
Tomatoes, Time of Planting

Time of Planting				Duration of Crop	Yield per acre s. tons	Percentage unsaleable fruit	Rainfall from planting to harvesting time (in.)
16-2-59	..	..	..	One month 2-6-59 to 2-7-59	21.9	19.1	9.68
16-3-59	..	..	..	Two months 11-6-59 to 11-8-59	10.2	20.9	8.52
16-4-59	..	..	..	2½ months 27-8-59 to 14-11-59	56.1	22.5	4.23
16-5-59	..	..	..	2½ weeks 29-10-59 to 14-11-59	39.2	21.5	0.89

The plants were irrigated by an overhead spray line about once monthly from March onwards. The results suggest that the tomatoes grow best when planted at the end of the rains which, in 1959, was mid-April.

The percentage of unsaleable fruit remained constant and was due, in the main, to attacks of late blight, *Phytophthora infestans*. The disease was controlled by spraying weekly until 26th August with a captan/dithane mixture; about 80 per cent. of the crop was harvested in a sound condition.

5. Peas. Time of Planting

Object.—To determine the effect of different planting times on the yield of peas. The canning variety *Wyola* was used.

Observation plots, 20 square yards in size were sown monthly at Bvumbwe for five successive months commencing at the beginning of February at a spacing of 2 feet $\times$ 1 inch $\times$ one seed. Drills were dressed with superphosphate at 250 lb. per acre.

Viability of seed was not good and germination was variable but sufficient to provide a good stand of plants. Plants were thinned to one every 3 inches. They were not staked.

TABLE IV
Peas, Time of Planting

Time of Planting					Percentage germination	Duration of Crop	Yield per Acre Green Pods, S. tons
5-2-60	..	..	..	..	60	20-4-60 to 18-5-60	9.47
5-3-60	..	..	..	..	80	18-5-60 to 9-6-60	5.44
5-4-60	..	..	..	..	50	4-7-60 to 3-8-60	5.23
5-5-60	..	..	..	..	40	19-8-60 to 10-9-60	9.58
6-6-60	..	..	..	..	40	10-9-60 to 24-9-60	5.14

The first planting had to be protected against cut worms with Kynadrin.

Plots were watered by hand once in April. The frequency had to be increased from May onwards to about three times weekly.

Best yields were obtained from crops produced at the end of the rains. As soon as temperatures rose in September, the period of cropping and yield were reduced.

6. Nurseries

A high percentage of successes was obtained in the vegetative propagation of avocados. Five- to six-month-old seedlings were saddle-grafted in September/October. Scion wood containing three buds was prepared from material which had previously been stored in a temperature of 35-50°F for two weeks. Material from which buds had fallen out during that period was rejected.

Extract from Report of the Plant Pathologist

TOMATOES

Late Blight (*Phytophthora infestans* (Mont) de Bary) was first recorded on tomatoes during the year under review. Widespread fruit rotting and foliage destruction was caused during the rains. During the dry season the disease appeared mainly on the fruit, causing quite severe damage. An irregular discrete brown lesion with a water soaked halo appears mainly at the blossom end of two or three fruits on each truss. The lesion rarely develops beyond this although occasionally secondary organisms cause rotting of the tissues. Leaf symptoms are rare, though lesions appear on petioles causing death of leaflets distal to the lesion. Lesions also occurred on the stem, occasionally girdling it to cause death of the upper parts of the stem.

Waf 109

CUCUMBERS

Downy mildew *Pseudoperonospora cubensis* (Berk & Curt) Rostovz was recorded for the first time this year. It appeared on dry season irrigated cucumbers in one area, and destroyed the crop completely. Powdery mildew, caused by *Erysiphe cichoracearum* DC. was common during the dry season.

Waf 108

LETTUCE

Lettuce mosaic virus was recorded for the first time this year on London Cos lettuce.

Waf

PEAS

Erysiphe polygoni DC. was common on pea crops grown during the dry season.

COCOA

Cocoa was introduced into Nyasaland in the early years of this century and was planted in a high rainfall area at Nkata Bay on the shores of Lake Nyasa. Although the trees have remained healthy there has not been a heavy crop. In 1952 some newer varieties were brought from Nigeria and growth and cropping have been poor, possibly due to combination of too little rain and too much shade.

The present series of trials began in 1957 when varieties of Amelonado, Amazon and Trintario were obtained from the West African Cocoa Research Institute. These were planted at Makanga in the lower part of the Shire Valley and grown under irrigation. Initially the trees were grown under a shade of bananas but this has now been removed as it appeared to be too dense. From the beginning growth has been rapid and only minor troubles from pests, diseases and deficiencies have, so far, been encountered. This first planting was only half an acre in size.

In the year under review the cocoa has continued to make remarkably rapid and vigorous growth especially amongst the Amazonian varieties. Trees of the most vigorous variety, T79, reached a height of 8 feet or more in less than 3 years whilst in the third year (November, 1959, to October, 1960) trunk girth at 1 foot from ground level was doubled (from 5 inches to 10 inches.) The quantity of leaf carried was well above normal as leaves are remaining on the trees considerably longer than the accepted three flushes.

Flowering began on the Amazonian varieties just before the trees were two years old and became very profuse even for cocoa. Pods were picked from the most advanced trees of variety T73 at 2½ years old.

Various abnormal leaf conditions have been observed and investigated without, as yet, definite conclusions being reached.

During the year the crop received irrigation water and rainfall as follows:

			<i>Irrigation</i>	<i>Rainfall</i>	<i>Total</i>
1st May to 31st October	..	..	38 inches	2.48 inches	
1st November to 30th April	..	..	12 inches	20.77 inches	
			<u>50 inches</u>	<u>23.25 inches</u>	<u>83.25 inches.</u>

In March, 1960, a further planting of six acres of cocoa was established at Masenjere, 12 miles north of the Makanga Experiment Station. The seed again came from W.A.C.R.I. and germination was excellent. The seeds were sown in polythene pots and planted out under a shade of pigeon pea. On the whole growth has been good in spite of some initial troubles in getting the irrigation system in working order. The border check system of irrigation was used but this has not proved wholly satisfactory for the young trees and in any further plantings the basin system will be employed.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

POTASSIUM DEFICIENCY

The symptoms, reported at Makanga in last year's report, have now disappeared, following the removal of the heavy banana shade. The potassium content of the cacao leaf has also increased from a range of 0.7-1.3 to 1.6-2.5 per cent., and this is particularly significant, as normally potash content would decrease with shade removal.

MICRO-NUTRIENTS

While it was encouraging to see the disappearance of the K deficiency effects, in the subsequent dry season other leaf symptoms occurred. These consisted of appreciable tip scorch, on leaf otherwise of normal colour and turgidity. Coupled with this was the less extensive occurrence of interveinal necrosis surrounded by bright yellow coloration on the Amazon variety the coloration being more white on the Amelonado. There was a small amount of sickle leaf and mottling on three-year-old trees at Makanga and at Masenjere there was extensive sickle leaf on 6 9-month-old bushes.

Samples were examined for macro- and micro-nutrient content, but there appeared no marked differences, which could signify clearly (as has been found previously in similar problems), that the cause was a macro- or micro-nutrient deficiency. The general lowness of copper may be important and there was a tendency for zinc to be low as seen from the range of figures shown below.

N		P		K		Ca		Mg
2.1-2.8	..	0.14-0.25	..	1.5-2.6	..	0.44-2.4	..	0.44-0.61%
B		Cu		Fe		Mn		Zn
41-63	..	2-5	..	38-160	..	57-115	..	15-27 p.p.m.

At Masenjere, the sickle leaf showed a lower zinc content 8-15 p.p.m. in affected leaf compared with 15-30 in good leaf especially when considered on a "per leaf" basis—but this might not possibly be inherent—but an indirect result of moisture shortage before irrigation commenced as reported in West Africa and the new flush seemed more satisfactory. The necrosis at Makanga seemed more predominant on the "sun" side of the trees, although this could also be related to wind and exposure. A micro-nutrient spray was applied—but no results were apparent after two months. In fact during this time the symptoms generally decreased and a climatic factor may be involved. The problem at Makanga may be related to the high amount of leaf being carried, and probably reduced irrigation might be beneficial both from this aspect, and also in forcing the roots to explore a larger volume of soil for micro-nutrients.

Extract from Report of the Entomologist

Odontotermes (Cycloptermes) mediocris (Sjost.), a termite, was recorded as damaging cocoa trees nearly three years old at Makanga. Possibly other species of termites were also implicated. A number of trees collapsed due to weakening by termites, but it could not be decided whether primary damage was due to the termites, mechanical damage or to a pathogen. It seems likely that the termite attack was secondary. A 1 per cent. solution of Dieldrin was used to control the termites.

Systates pollinosus Gerst., a weevil, attacks the young leaves and growing points but has not been numerous on cocoa this year. This weevil, which normally lives on mango and other local plants, became a minor pest of cocoa in the first season of the crop. The weevil attacks citrus also.

An attack of mealy-bug (*Pseudococcus* sp.) on cocoa less than one year old at Masenjere in the Lower River was controlled with Rogor 40. On Makanga small numbers of *Pseudococcus adonidum* L. occurred on new shoots on a few trees.

Extract from Report of the Plant Pathologist

Colletotrichum sp. (conidial *Glomerella cingulata* (Stonem) Spauld & Schrenk) caused an angular leaf spot on the young leaves of cacao. It also caused a pod rot, and in the latter phase may well become serious in the rather severe climatic conditions of the lower Shire River valley.

Root knot nematode *Meloidogyne javanica* was found to be present on unthrifty trees. The above-ground symptoms are merely those of slow growth, and difficulty is encountered in establishing the young plants in infested patches. On the roots galling does not occur, but slight irregularities are present where the female nematodes are embedded. Bananas are being used as a nurse shade. Should the nematodes prove to be serious obstacles in the culture of the cacao tree, it would be advisable to seek another nurse shade as bananas have been shown to be excellent hosts of *M. javanica*, and were found to be heavily infected in this case.

GRASSLAND

1. Grass Variety Trial

An experiment to evaluate six species or strains of grasses was started in 1956/57 season on red/brown sandy loam soil at Chitedze using an alternate mowing and grazing technique, with the return of clippings, developed by Hudson (1933) in New Zealand and described by D. Brown in Bulletin No. 42 of Commonwealth Bureau Field Crops (page 110). The results to date were given in last year's report.

The experiment is laid out as a randomized block with four replications having the plots split for nitrogen at 400 lb. per acre per annum of sulphate of ammonia versus nil. This is applied in two 200 lb. dressings, one at the onset of the rains and one after the first defoliation.

The results for the 1959/60 season are summarized in Table I. Each plot was cut twice and grazed twice during the course of the season.

TABLE I
Dry Matter Yields in short tons per Acre
(Crude Protein as percentage of dry matter)

	With Fertilizer N.		Without Fertilizer N.		Variety Mean
	Dry Matter	Mean Protein %	Dry Matter	Mean Protein %	Dry Matter
<i>Setaria sphacelata</i>	2.32	10.95	1.52	9.13	1.92
<i>Cynodon dactylon</i>	3.02	11.88	1.88	11.16	2.45
<i>P. coloratum</i> v. <i>makavikariensis</i> ..	3.22	10.20	1.68	8.84	2.45
<i>Chloris gayana</i> (Katambora) ..	2.82	10.26	1.72	9.00	2.27
<i>Chloris gayana</i> (Mpwapwa) ..	2.38	11.85	1.58	9.45	1.98
<i>Cenchrus ciliaris</i>	3.42	11.17	2.08	9.92	2.75
Mean effect of Nitrogen ..	2.86		1.74		

L.S.D. for the mean effect of Nitrogen $P0.001=0.39$ tons per acre

L.S.D. for variety means $P0.01=0.22$ tons per acre

Co-efficient of Variation 5.7%

Table I shows that *Cenchrus ciliaris*, *Cynodon dactylon* and *P. coloratum* were the top yielding grasses. The stands of Mpwapwa *Chloris* and the *Setaria* stands have deteriorated markedly in this the fourth year since establishment.

The application of sulphate of ammonia increased the mean dry matter production by 1.12 tons per acre which was significant at the $P0.001$ level. There was a significant ($P0.01$) nitrogen/varieties interaction.

2. Rhodes Grass Carrying Capacity Trial

This experiment was described in last year's report. The object is to test the possibility of maintaining cattle throughout the year at Chitedze on red/brown sandy clay loam soils solely with the produce of Rhodes grass (*Chloris gayana*) pastures. The treatments are: (A) Rhodes grass unfertilized, with hay and silage saved for the dry season: (B) similar management, but with 400 lb. of sulphate of ammonia top dressed per year: and (C) Rhodes grass to be used *in situ* giving rains grazing and dry season foggage.

The period now reported is from December, 1959, to November, 1960. During this period the (A) and (C) treatments were stocked at the rate of one beast to two acres, except in December and January when there was a beast to every one and a half acres. The stocking rate on the (B) treatment was a beast per acre throughout.

The animals on the (A) treatments were fed hay at the rate of 6 lb. per head per day from 19/5/60, and silage at 10 lb. per head per day from 1/6/60 to the end of the experiment. The surplus rains production cut for conservation was more than adequate on both treatments to meet the full dry season needs. However, too much silage and too little hay were made on the (B) treatments with the result that at the end of September the cattle on this treatment had no hay and were fed solely on an increased silage ration until the end of the experiment.

Liveweight gains are shown in Table II.

TABLE II
Mean Liveweight gains in lb.

	A		B		C	
	<i>Per acre</i>	<i>Per beast</i>	<i>Per acre</i>	<i>Per beast</i>	<i>Per acre</i>	<i>Per beast</i>
December 1959	+10.0	+15.0	+12.0	+12.0	+1.5	+2.0
January 1960	+8.0	+13.0	+6.0	+6.0	+16.0	+25.0
February	+12.0	+24.0	+48.0	+48.0	+26.0	+52.0
March	+19.0	+38.0	+36.0	+36.0	+19.0	+38.0
April	+18.5	+37.0	+15.0	+15.0	+6.0	-12.0
May	-4.5	-9.0	-15.0	-15.0	-1.5	-3.0
June	+16.0	+32.0	+42.0	+42.0	+0.5	+1.0
July	-1.0	-2.0	-7.0	-7.0	-9.5	-19.0
August	-9.0	-18.0	-20.0	-20.0	-5.0	-10.0
September	-2.5	-5.0	-7.0	-7.0	-5.5	-11.0
October	+3.5	+7.0	-29.0	-29.0	-8.0	-16.0
November	-7.5	-15.0	-13.0	-13.0	-7.5	-15.0
Net gain 1959/60	48.1	117.0	68.0	68.0	20.0	32.0
Net gain 1958/59	48.1	145.0	105.5	167.0	55.5	176.0

In discussing these results it must be kept in mind that this has been an exploratory experiment and the first of its kind to be run under the conditions of the Nyasaland central plateau. The first conclusion is that the stocking rates used in 1958/59 were more correct than the heavier rates used in 1960/61, although, of course, the ley was a year older and grass productivity may have been less in the latter year. As interim advice, however, it can be said that unfertilized leys utilized either under system (A) or system (C) should be stocked at the rate of two and a half to three acres to the beast, and fertilized leys using system (B) can carry a beast to one and a half acres. Secondly, a liveweight gain per beast (in this case Nyasaland shorthorn Zebu) of from 150 to 200 lb. can be expected between December and June for bullocks of between 600 and 900 lb. liveweight grazed on Rhodes grass leys. The loss from July to November on systems (B) and (C) averaged approximately 50 lb. per beast over the two years. On treatment (A) the loss during the same period was about 30 lb. per beast. There is little doubt that the difference between (A) and (B) in this respect is due to a supplementary bite of small shoots from the Rhodes grass during the height of the dry season. The animals on the (A) treatment had double the acreage per head from which to glean this supplement. The effect of this grazing in retarding the initial grass growth at the beginning of the next rains is most marked.

Finally, the use of 400 lb. of sulphate of ammonia can approximately double the productivity of a Rhodes grass ley.

3. Napier Grass Spacing and Fertilizer Trial

A single replication of a 3³ factorial experiment was established 1957/58 on red/brown sandy clay loam soil at Chitedze, to investigate the nitrogen and phosphate responses of Napier grass (*Pennisetum purpureum*), Cameroons strain, at three different spacings. The manurial treatments were 0, 300 lb. and 600 lb. per acre of sulphate of ammonia per year, and similar levels of single superphosphate. The phosphates were applied in the ridge at planting and in subsequent years, band placed on either side at the onset of the rains. The nitrogenous fertilizers were split to give two equal applications during the growing season.

The spacings were S₀, 3 feet × 3 feet; S₁, 9 feet × 3 feet; S₂, 9 feet × 1 foot. The population per acre was, therefore, similar for S₀ and S₂.

The results of the first harvest year of the experiment were given in the 1958/59 report. Total dry matter yields for 1959/60 are given in Table III (A). There were three wet season cuts taken on 9/1/60, 23/2/60 and 11/5/60, and one dry season cut taken on 19/10/60. Analytical data for each harvest is summarized in Table III (B). Soil samples were taken during the dry season, that is after three years of the experiment's productive life, and these are summarized in Table III (C).

TABLE III (A)
Dry Matter Yields 1959/60 season as 100 lb. D.M./acre

	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	Mean
S ₀	88	115	116	92	103	124	106
S ₁	71	102	100	66	104	103	91
S ₂	87	97	105	76	116	97	97
P ₀	75	82	78				
P ₁	92	107	123				
P ₂	79	125	120				
Mean	82	105	107	78	108	108	

L.S.D. Marginal Means P0.05=6.81; P0.01=10.29; P0.001=16.57
Co-efficient of Variation=6.02%

TABLE III (B)
Percentage Composition of Napier Grass

	Cut	Fertilizer			
		N/P 00	N/P 20	N/P 02	N/P 22
Dry Matter ..	1st	13.3	13.2	13.4	13.5
	2nd	12.8	13.1	14.7	14.8
	3rd	22.0	19.7	20.1	19.9
	4th	22.3	27.3	27.5	28.6
Crude Protein ..	1st	15.1	16.2	12.7	15.2
	2nd	9.9	13.2	6.9	8.4
	3rd	7.5	8.3	5.4	6.1
	4th	8.4	8.9	4.2	5.4
Phosphate ..	1st	0.20	0.20	0.24	0.24
	2nd	0.18	0.14	0.24	0.24
	3rd	0.11	0.13	0.12	0.11
	4th	0.11	0.07	0.05	0.06
Potash	1st	4.65	4.22	4.38	4.22
	2nd	5.16	4.54	4.11	3.68
	3rd	3.25	3.17	2.66	2.42
	4th	3.44	2.76	2.58	2.58

TABLE III (C)

Soil Analyses

	Depth	Fertilizer			
		N/P 00	N/P 20	N/P 02	N/P 22
pH.	0-6"	6.0	6.1	5.9	5.6
	6-12"	5.9	5.7	5.9	5.5
%N	0-6"	.167	.177	.165	.163
	6-12"	.156	.168	.155	.159
Phos. p.p.m. . .	0-6"	6.3	4.7	42.0	43.0
	6-12"	3.0	2.0	22.0	36.0
K m.e.%	0-6"	.31	.28	.23	.23
	6-12"	.22	.18	.15	.14

The dry matter yields show that applications of N and P fertilizers both significantly increased yields (P0.001) at the lower levels of application, but in neither case did increasing the dressing result in still greater yield. There was a significant (P0.01) N.P. interaction.

The S_0 spacing significantly (P0.01) outyielded S_1 and at the (P0.05) level outyielded S_2 . These results are generally in agreement with those previously recorded.

Referring to Table III (B) it should be noted that the growth for the third cut had taken place initially in wet season conditions but for six weeks prior to cutting had had little rain. From previous work by the soil physics section at Chitedze it can, therefore, be concluded that the top soil will have dried out and the grass will have been obtaining its moisture and nutrition from some depth. During the first two cuts fertilizing clearly influenced the crude protein and phosphate contents of the crop. In the third and fourth cut the effect of phosphate fertilizing did not show in the leaf but there still appeared to be a nitrogen effect on crude protein. The use of fertilizers, both N and P separately, and particularly N.P. together, has given increased yields throughout this experiment, and the effect of the removal of these heavier yields is clearly shown by Table III (C) in the reduced soil potash. This is reflected in the potash percentage in the leaf. Table III (C) also shows that soil phosphate has reached a very low level which would be limiting for most crops where no phosphatic fertilizer has been used on the Napier grass.

Grass Trials, Bvumbwe

1. FERTILIZER EXPERIMENT ON PERMANENT PASTURE

This experiment (see 1957/58 report) is a permanent pasture of Star Grass mixed with some Rhodes and *Panicum makarikari*; it is on a sandy soil at Bvumbwe containing only 7-11 per cent. silt and clay to a depth of three feet. The objects are to assess the reaction to three kinds of nitrogenous fertilizers with and without phosphate, sulphur and lime. The experiment, which is in its third year, is a randomized block layout with four replicates each plot being 1/12th acre in size. Treatments are shown in Table IV. Blocks are mown and grazed alternately. The mowings are removed as for silage or hay making. After grazing the plots are topped by a mower and these mowings are not removed.

TABLE IV
Fertilizer Experiment on Star Grass, Bvumbwe
(Yield, lb. per acre)

Treatment	1959			1958-60 Mean Dry Matter	Acidity (pH)		
	Dry Matter	Equiv. Protein	1960 Dry Matter		1958	1960	Decrease
1. Control (Nil) ..	2,093	105	1,011	1,236	5.9	5.6	0.3
2. Sulphate of Ammonia, 400 lb./acre ..	3,097	220	2,508	2,442	5.9	5.3	0.6
3. 2 + Dolomite, 845 lb./acre ..	3,011	166	1,462	1,941	5.7	5.7	—
4. Sulphate of Ammonia, 800 lb./acre ..	4,240	314	3,583	3,484	5.7	5.1	0.6
5. 4 + Dolomite, 845 lb./acre ..	3,687	284	2,538	2,885	5.8	5.4	0.4
6. Nitramoncal, 800 lb./acre ..	3,797	308	3,038	2,900	5.7	5.6	0.1
7. 6 + Gypsum, 1000 lb./acre ..	3,472	285	2,228	2,529	5.6	5.5	0.1
8. Urea 46%, 175 lb./acre ..	2,516	174	1,968	2,022	5.6	5.5	0.1
9. Urea 350 lb./acre ..	3,889	292	2,147	2,789	5.9	5.5	0.4
10. 9 + Single Supers, 440 lb./acre ..	3,931	271	2,547	2,861	5.8	5.6	0.2
11. 9 + Triple Supers, 175 lb./acre ..	3,723	320	2,820	3,117	5.5	5.5	—
12. 9 + Gypsum, 1000 lb./acre ..	3,255	251	1,932	2,497	5.6	5.6	—
Lowest Sig. Diff. $p=0.05$	977	76	1,029	650($p=0.01$)			
Coefficient of Variation ..	20.0%	21.4%	30.8%	11.0%			

As in previous experiments on star grass and rhodes grass, sulphate of ammonia (treatments 2 and 4) was the nitrogen fertilizer which obtained the highest yields of grass. Equivalent levels of nitramoncal and urea (treatments 6, 8 and 9), although they gave significant responses over control, were less effective, the difference between the high levels of urea and sulphate of ammonia being significant.

It was thought from previous experiments that the acidifying effect of sulphate of ammonia might, in the long run, produce an adverse effect. Its superiority over nitramoncal might have been due to its sulphur content. In this experiment the addition of dolomite (treatments 3 and 5), which helped to counteract the acidifying effect of sulphate of ammonia, considerably reduced the response to that fertilizer. The low pH levels induced by sulphate of ammonia have not, at this stage of the experiment, adversely affected the star grass even on a soil as poorly supplied with bases as that on which the experiment is situated. Sulphur does not appear to be an important factor for, when it is added to nitramoncal or urea in the form of gypsum, the yield is reduced.

Phosphate, when added to urea, particularly in the form of triple superphosphate, shows a tendency to increase the response to nitrogen. This may be an important factor where a dairy herd is run on the pasture.

Yields in all plots were low due to the extremely light soil on which the experiment was planted and the abnormally low rainfall during the period of recording. Rainfall was at its lowest in 1960 with a shortfall of 9 inches.

Protein determinations were made from samples taken in 1959. Although there were no significant differences between the results of these analyses (see column 2 of Table IV), there was a strong correlation ($r=0.9265$) with the yield figures in which there were significant differences between the fertilizer treatments.

A check was kept on any change that might occur in the plant population as a result of the fertilizer treatments. Samples were sorted in the laboratory and counts made in the field by the step-point method. At the beginning of the experiment the population of planted grass was low in all plots, about 27 per cent. being weeds. As soon as the nitrogenous fertilizers were added, the proportion of star and, to a lesser degree, of rhodes increased. The proportion of makarikari, which is not strongly creeping, has remained constant. The greatest suppression of monocotyledonous and dicotyledonous weeds had occurred on the plots receiving the high rates of sulphate of ammonia and urea (treats. 4, 5, 9-12). The population of undesirable grasses *Sporobolus* and *Rhynchelytrum* has varied markedly; in the control and low fertilizer plots (treats. 1-3, and 8) their numbers were greatest. Acknowledgement is made to Messrs. Tobacco Auctions who supplied the urea for this experiment.

2. GRASS/LEGUME EXPERIMENT

Object.—To compare at Bvumbwe the productivity of grass when interplanted with a legume with its productivity when treated with a nitrogenous fertilizer.

The soil is a very light sandy loam, similar to the previous experiment, with lateritic outcrops. The experimental design is a 2^4 factorial with plots 100 square yards in size. Plots are separated with guard alleys of *Paspalum notatum*.

The experiment was planted in 1958/59 and the first recordings made this year.

Treatments—

G₁—Mpwapwa Rhodes grass

G₂—"Grassland" *Cenchrus ciliaris* + Nachingwea creeping makarikari

D—*Desmodium intortum*

S—*Stylosanthes gracilis*

N—400 lb. sulphate of ammonia per acre per annum in two split applications.

Superphosphate, 100 lb. per acre, was applied as an overall dressing.

TABLE V
Grass/Legume Experiment, Bvumbwe

	(1)	D	S	DS	Mean	L.S.D.
1. Yield, dry matter, lb. per acre						
G ₁ Rhodes Grass without N	2,032	3,840	2,406	5,557	3,459	p=0.05 2489
G ₁ Rhodes Grass with N	5,663	4,922	5,480	8,327	6,098	
G ₂ <i>Cenchrus</i> etc. without N	3,994	7,707	4,231	3,810	4,936	
G ₂ <i>Cenchrus</i> etc. with N	7,112	4,531	6,700	6,786	6,282	
Mean	4,700	5,250	4,704	6,120	5,194	
2. Crude Protein, per cent. dry weight basis.						
G ₁ Rhodes Grass without N	7.8	10.9	11.7	8.1	9.6	Not significant
G ₁ Rhodes Grass with N	8.1	10.2	6.4	7.2	8.0	
G ₂ <i>Cenchrus</i> , etc. without N	10.5	13.8	12.4	16.2	13.2	
G ₂ <i>Cenchrus</i> , etc. with N	6.4	10.8	12.6	9.5	9.8	
Mean	8.2	11.4	10.8	10.3	10.2	

Three cuts of rhodes grass were taken—in December, February and May—and four of the *Cenchrus* mixture—in December (2), March and May.

The results show that in the case of rhodes grass the yield of green matter in the plot containing both legumes was about the same as from rhodes grass without legume but fertilized with sulphate of ammonia. The *Cenchrus*/makarikari mixture produced higher yields than rhodes grass. The protein content of the *Cenchrus*/makarikari mixture was also greater than that of the rhodes grass. When either or both of the legumes were present, the feeding value of the dry matter was enhanced. There is a decrease in the protein content when nitrogen is applied apparently due to a higher growth rate inducing a higher C/N ratio.

The ratio of grass to legume in the *Cenchrus* mixture was about 68:32 and in the more aggressive rhodes grass about 75:25.

3. IRRIGATED PASTURES

One-acre plots of lucerne and a chicory/clover/fescue mixture were established at Bvumbwe in January, 1958, on an area previously planted to granadillas. South African standard seed of lucerne was sown in 18 inch drills at 20 lb. per acre. The seed was inoculated. Germination and establishment were good. The chicory mixture of French agricultural chicory (6 lb.), meadow fescue (3 lb.), late flower red clover (2 lb.) and white clover, S.100 (4 lb.) was sown similarly at 15 lb. per acre. The clovers were inoculated. Germination was good except for the fescue which was poor.

Both plots had previously been limed at 25 cwt. per acre and top-dressed at sowing time with superphosphate at 200 lb. per acre. Subsequently the plots were fertilized with C.A.N. (calcium ammonium nitrate) at 200 lb./acre and superphosphate at 100 lb./acre once at the beginning of the rains and once at the end of the rains.

Half of each plot was irrigated when necessary with a sprinkler spray line delivering 1/3rd inch of water per hour. The need for irrigation was determined with the aid of a water balance sheet from data provided by an evaporation pan. The plots were irrigated when the deficit reached a figure of 2 inches. In 1959 a factor of 0.8 was applied but this did not appear sufficient to prevent wilting when the lucerne had exceeded a height of six inches.

In 1960 a factor of 1.0 was used when the stems were 0-6 inches high and of 1.2 when over 6 inches in height.

The plots were cut and recorded when the irrigated sections were ready for cutting. In the case of lucerne this was just before flowering; the chicory plot was usually in a fit state for cutting at the same time, leaf being plentiful and flower stems not having developed.

TABLE VI
Irrigated Pastures, Bvumbwe
(Weight (lb.) dry matter per acre)

Date Cut	Lucerne		Chicory Mixture	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated
3- 4-59	613	956	663	405
30- 5-59	1,004	776	755	933
20- 7-59	741	207	833	382
8- 9-59	2,026	247	207	Nil
27-10-59	1,203	118	446	82
26-11-59	2,123	818	1,004	969
Mean for season	1,285	520	651	462
12- 1-60	1,256	1,144	934	644
8- 3-60	1,022	1,064	673	668
10- 5-60	410	493	565	253
5- 8-60	853	337	Discontinued	
16- 9-60	1,648	332		
19-10-60	1,307	Nil		
Mean for season	1,048	485	619	460

The first records were taken in April, 1959. The crops were valued for the dry season feed which they provided. Table III shows that a cut could be expected from the lucerne about every six weeks in the dry season. Yields were not high and were so disappointing in the chicory plots that that part of the trial was discontinued. In 1960 an additional cut could have been obtained in June/July and the yields for May and August would have been higher if there had not been a breakdown in the water supplies. The frequency of irrigation increased from every six weeks to monthly and then every three weeks as the season advanced.

Higher yields are required and this is being investigated further on the basis that insufficient water was supplied in these trials and that the frequency of fertilizer applications could be increased.

The leaves were attacked by a leaf rust during the rains which persisted to the dry season if not controlled with a Bordeaux mixture spray.

Extract from Report of the Senior Agricultural Chemist, Bvumbwe

ACIDIFYING ACTION OF FERTILIZERS

Soils from the "Forms of N" experiment on star grass at Bvumbwe have been examined at two years treatment. As would be expected the S/A has had the greatest effect giving a pH of 5.3 at 400 lb., and 5.1 where 800 lb. has been applied. The

control plots have also decreased from 5.9 to 5.6. Application of dolomite or N/A reduces the acidity effect, while the addition of supers+urea leaves the soil unchanged in pH—urea itself having a slight acidifying action. The interesting thing is that S/A is still by far the most effective form of N—as far as yield is concerned. The difference in effect of pH on grass (and also maize) between Southern Rhodesia and this territory has been noted before—and warrants further examination. It is most likely due to the fact that at the same pH, the Nyasaland soils are generally better supplied with bases than are soils from Southern Rhodesia, often derived from more acidic rocks.

HYDROCYANIC ACID IN STAR GRASS

Towards the end of the dry season there were several instances of possible HCN poisoning of calves from star grass. Samples of grass have contained up to 180 p.p.m., and liver 22 p.p.m., while stomach contents have contained less. This liver content represents 2 mg. per Kg. which could be lethal and as only calves have been affected this may have been the cause, particularly as there is necessarily some delay in getting the samples to the laboratory. It is possible that with the unseasonable rains that have occurred, there has been a sudden quick flush of nitrogen to give fresh shoots with high HCN content. The occurrence of the highest HCN level on grass from an anthill supports this possibility.

ROTATION EXPERIMENTS

1. Time of Ploughing Rhodes Grass Leys

(a) At Chitedze the grass was ploughed out at three times of the year, with and without dressings of sulphate of ammonia applied to the grass before ploughing and to the following maize crop. Both maize and groundnuts were used as test crops. The design was a 3×2 factorial design with plots split for the four nitrogen treatments, and there were three replications. The two levels of organic matter turned in were in point of fact alike, as the grass did not grow appreciably after the silage cut taken at the end of January. The ploughing treatments all yielded alike, though the earliest ploughed plots appeared to get away to a bad start, and there was no response to nitrogen applied just before ploughing. The response to nitrogen applied to the maize was, however, clear.

TABLE I

Effects of Time of Ploughing Rhodes grass at Chitedze

Varieties: Mithenga and Mwitunde

Yield: lb./acre grain and
shelled nuts

Treatment	Yield of Maize	Yield of Groundnuts
Plough 10/2/59 plant beans catch crop ..	4,300	1,060
Plough 24/2/59, rotavate and fallow ..	4,410	1,170
Plough 25/3/59, fallow ..	4,420	1,250
L.S.D. 5%	500	None
Nil	4,320	1,220
100 lb. S/A applied to grass before ploughing	4,430	1,100
L.S.D. 5%	310	None
Nil	4,200	—
200 lb. S/A applied direct to Maize ..	4,550**	—
L.S.D. 5%	180	—
Coefficient of Variation	8.5%	19.1%
Mean	4,375	1,160

(b) At Tuchila, six ploughing treatments were replicated three times, and the plots were split for the presence or absence of 200 lb. per acre sulphate of ammonia applied to the maize test crop. There were again no significant differences between the yields produced by the ploughing treatments, though there was a large response to nitrogen. The earliest ploughed plots again looked poor early in the season and produced more barren plants and smaller cobs. Grazing appeared to be no more beneficial than cutting, burning, etc.

TABLE II

Effect of Time of Ploughing Rhodes grass at Tuchila

Variety: Namlenga

Yields: lb./acre grain

Treatment						Yield	Barren Plants	lb. per cob.
A	Plough	January	after grazing	..	..	1,720	3,100	.170
B	Plough	February	after grazing	..	..	2,020	1,800	.204
C	Plough	March	after grazing	..	..	2,200	1,700	.212
D	Plough	January,	no grazing	..	..	1,680	3,600	.193
E	Plough	October,	after a silage cut in Feb. and burning in October	..	..	1,640	2,400	.153
F	Plough	February,	after silage cut	..	..	2,010	700	.200
	L.S.D. 5%	..	..	..	..	None	—	—
	Nil	..	..	..	..	1,555	2,900	.160
	200 lb. S/Ammonia applied to Maize	..	..	..	..	2,195	1,500	.217
	L.S.D. 5%	..	..	..	..	665	—	—
Coefficient of Varn.						24.7%	Mean	1,875

It would appear then that unless a catch crop is to be grown, Rhodes grass leys should be ploughed up between mid February and mid March. There is little point in applying nitrogen to the turf before ploughing, though a large response to nitrogen is likely if it is applied to maize grown in the first arable years. The grass should be grazed or cut down before ploughing to enable a good job to be done by the plough. Earlier ploughing may be recommended if a catch crop of beans, cowpeas or sweet potatoes is to be grown, as these will need to be planted before the middle of February, and will warrant a weeding to remove regrowth of the Rhodes grass.

2. Effect of Crop on Crop, Chitala

In this experiment seven crops were grown in the first year in randomized blocks with nine replications. In the second year three replications were planted to maize, three to groundnuts and three to cotton. Unfortunately a combination of poor soil and neglect over a difficult period in the station's running gave rise to poor yields and small differences. Under Lake-shore conditions it is still best not to plant two successive crops of maize or groundnuts, though cotton is less sensitive to previous cropping and cultivation than it is to pest and disease. Green manuring gives no better yields than do the other crops.

TABLE III

Effect of Crop on Crop at Chitala

Yields: lb./acre grain, shelled nuts and seed cotton

Varieties: Local, Mwitunde and CLB.

Previous crop						Maize	Groundnuts	Cotton Grades I and II
Maize	..	..	..	..	..	680	1,070	410
Maize with 200 lb. S/Ammonia	..	..	..	..	..	900	1,070	390
Groundnuts	..	..	..	..	..	1,430*	900	435
Cotton	..	..	..	..	..	1,800*	1,010	440
Cassava	..	..	..	..	..	1,590*	850	320
Sesame	..	..	..	..	..	1,620*	950	345
Green Manure	..	..	..	..	..	1,840*	1,030	380
L.S.D. 5%	..	..	..	..	..	440	200	115
Coefficient of Variation	..	..	..	..	..	17.5%	11.1%	16.8%
Mean	..	..	..	..	..	1,410	980	390

The cotton was late picked and badly damaged by pest.

3. Mphanje C Experiment, Chitedze

This short term rotation experiment on land ploughed out of Rhodes grass in February, 1958, and February/March, 1959, shows again that groundnuts benefit a following maize or tobacco crop on the plateau soils, and that the first crop after ploughing a Rhodes grass ley should be groundnuts or tobacco, unless substantial dressings of nitrogen can be applied to maize. It also shows that late ploughing of the ley is only detrimental if maize is to follow it. There were considerable responses to both N and P on this site.

TABLE IV

Results of Mphanje C Experiment, 2nd year

Varieties: Mthenga, Mwitunde, Western

Yields: lb./acre grain, shelled nuts and cured leaf

Treatment	Maize Yields	Groundnut Yields	Tobacco	
			Yields	Grade Index
After Maize	—	1,100	585	15.1
After Groundnuts	4,630**	—	710	16.6
After Tobacco	4,200*	1,010	—	—
After grass ploughed 25/2	4,050	1,120	700	20.1
After grass ploughed 25/3	3,600	1,240*	760*	23.9
L.S.D. 5%	500	135	145	—
O — Nil	4,130	1,075	650	18.9
P — 200 lb./acre Supers (residual in tobacco)	4,710***	1,120*	645	15.8
L.S.D. 5%	320	50	100	—
O — Nil	4,090	1,045	560	15.0
M { 200 lb. S/A on Maize 200 lb. 'C' & 100 S/A Tob. Residual effects G. Nuts }	4,750***	1,060	790***	20.8
L.S.D. 5%	320	95	100	—
Coefficient of Varn.	10.9%	7.1%	13.1%	—
Mean	4,120	1,100	675	17.9

Rotation Experiments at Bvumbwe

1. SOYA AFTER RHODES GRASS AND MAIZE

A five-year-old nitrogen fertilizer experiment at Bvumbwe on the "Teso" strain of rhodes grass has been reported previously (Part II Report for 1956/57, page 56). The residual effect of the fertilizer and the effect of early and late ploughing of the grass was observed on maize (Part II Report, 1957/58). The series of trials was completed this year when a further test crop, of soya, was planted.

The fertilizers on the rhodes grass were sulphate of ammonia (21.0 per cent. N) and nitramoncal (20.6 per cent. N), each at the following levels: 100, 200 and 300 lb. per acre every three months and 100 lb. per acre every month. 150 lb. per acre sulphate of ammonia was applied throughout the maize at planting time. The soya was not fertilized but the seed was inoculated.

Date planted.—5-12-59 with Volstate variety in a double line at 6 inches × 6 inches spacing on ridges 3 feet apart.

Date harvested.—4-5-60.

TABLE I

Soya after Rhodes Grass and Maize, Bvumbwe

<i>Treatment</i> (N/A = Nitramoncal S/A = Sulphate of ammonia)	<i>Rhodes Grass</i> <i>Mean yield per</i> <i>Year, 1954-57</i> <i>lb. per acre</i>	<i>Maize</i> <i>Shelled,</i> <i>lb. per</i> <i>acre</i>	<i>Soya</i> <i>Clean seed,</i> <i>lb. per</i> <i>acre</i>
Control (Nil)	4,600	2,730	1,407
100 lb./acre N/A every three months	11,600	3,284	1,433
100 lb./acre S/A every three months	12,600	3,186	1,427
200 lb./acre N/A every three months	12,800	3,318	1,433
300 lb./acre N/A every three months	15,200	3,206	1,327
200 lb./acre S/A every three months	15,800	3,288	1,460
100 lb./acre N/A every month	18,400	3,232	1,440
300 lb./acre S/A every three months	20,200	2,786	1,513
100 lb./acre S/A every month	24,600	2,876	1,207
Mean	15,100	3,101	1,405
L.S.D. $p=0.01$	4,200	74	188
Coeff. of Variation	21.3%	10.7%	8.6%

The soya yields show no significant differences between any treatments except for the sulphate of ammonia applied every month. In this treatment the yields were lowest. The same treatment gave significantly low yields in the maize test crop.

The results of this experiment are of practical importance in the management of the Mixed Farm Unit. A rhodes grass ley responds more to sulphate of ammonia than to nitramoncal (or nitro-chalk). The economics of the fertilizer have been discussed elsewhere; although the high dressings of ammonium sulphate appear to produce a profitable return, the farmer in Nyasaland is not yet prepared to expend such a sum and a compromise of 400-600 lb. per acre, applied in split dressings, is being recommended.

The yield of a rhodes grass ley decreases in the fifth year and subsequently. Therefore four years would appear to be the optimum life for a ley. If the first arable crop after the ley is maize, the best maize yields are obtained by ploughing early and from the medium rates of both sulphate of ammonia and nitramoncal. High fertilizer rates on the grass resulted in lower yields from the following crop. Except for the monthly application of sulphate of ammonia treatment, no residual effect of the fertilizers on the ley could be detected from the yields of the second arable crop, soya.

References

"1953/54 Grassland Investigations." *N.F. & F.* 2 (3) Oct., 1954.

"Some Nutritional Aspects of Established Pastures."

—C. V. Cutting and L. J. Foster. *N.F. & F.* 4 (2) Apr., 1958.

2. CONTINUOUS CROPPING OF MAIZE

The object is to observe the effect of continuous maize cropping at three nitrogen fertilizer levels.

The site is a tung field at Bvumbwe with young trees at a spacing of 27 feet square. The soil is a light sandy loam with lateritic outcrops.

The design is a randomized block with 8 replicates and plots of 0.126 acres in size; the experiment forms part of an "intercropping of tung" trial.

Treatments are: (i) 250 lb. sulphate of ammonia per acre,
(ii) 400 lb. sulphate of ammonia per acre,
(iii) 600 lb. sulphate of ammonia per acre.

Half of the fertilizer is applied in June just before the maize stover is disked in. The land is ridged in October. The other half of the fertilizer is applied three weeks after planting. The maize is planted at 3 feet $\times$ 1 foot $\times$ 1 plant.

TABLE II
Continuous Cropping of Maize, Bvumbwe

<i>Treatment</i>	<i>Yield shelled maize, lb. per acre</i>	
	1959	1960
Sulphate of ammonia, 250 lb./acre ..	3,043	3,787
" " 400 lb./acre ..	3,213	4,294
" " 600 lb./acre ..	2,993	3,934
	Not significant	
Coefficient of Variation	8.6%	10.0%
Variety planted	Synthetic 13	Sahara

Good yields were obtained and there was no increase in yield due to the high rates of fertilizer suggesting that, on this soil, several crops of maize could be taken before additional fertilizer is required to that normally used in a rotation.

FARMING SYSTEMS

Mixed Farm Unit, Bvumbwe

The 100-acre Farm Unit, combining 24 acres of arable, 32 acres of ley and 44 acres of permanent pasture, is now carrying one cow equivalent to 2.6 acres (see Table below).

TABLE I
Stocking Rate of 100-acre Farm, 1960

<i>Cattle</i>			<i>Cow Equivalents</i>	<i>Pigs</i>			<i>Cow Equivalents</i>
1 Bull	..	..	1	1 Boar	..	..	0.5
17 Cows in milk ..	..	..	21.3	7 Sows and Gilts	..	..	3.5
5 Heifers	..	..	4	37 Growers and	..	..	2.9
6 Yearlings	..	..	3	Fatteners	..	..	
7 Calves	..	..	2				
			<u>31.3</u>				<u>6.9</u>
Total all stock ..	..	..	38.2	Acres per unit ..	..	..	2.6

The estimated maximum stocking rate is one unit to 2.0 acres; this has not yet been attained, not because the farm is already overstocked—there is still room for expansion—but because the pig section could not develop as originally intended. There is a very limited local market for pig products and no increase in production could be absorbed. The Jersey herd has multiplied at a satisfactory rate, a reasonable proportion of heifers to bull calves having been obtained. One cow reacted positively to a contagious abortion test and was slaughtered. The herd has been tested for tuberculosis and no reactors were found. The performance of the herd is shown in Table II below.

TABLE II
Bvumbwe Jersey Herd, Milk Yields
Mean yield per cow (lb. per 300-day lactation)

<i>Year</i>	<i>First lactation</i>	<i>Second lactation</i>	<i>Third lactation</i>	<i>Mean</i>
1957/58	6,240(4)*	7,958(1)	—	6,584
1958/59	5,311(4)	6,897(4)	—	6,104
1959/60	4,877(7)	5,724(6)	6,696(5)	5,747

*Number in brackets indicates number of cows recorded.

The mean yield per cow for the herd over the years 1957/60 has decreased. There has been no decline in individual milk yields from the first to second and third lactations but there are some very low yielders, which will have to be culled, in the second batch of imported heifers. The average butterfat content was 5.37 per cent. 10,494 gallons of milk were produced at a cost of 20.85 pence per gallon. This figure does not include overheads. The previous year's production was 8,972 gallons at a cost of 24.6 pence per gallon.

The arable section is run on a seven-course rotation of maize, soya, maize, four-years ley. Costs of production are shown in the Table below.

TABLE III
Bvumbwe Mixed Farm Unit
(Costs of Production of Various Crops, 1959/60)

<i>Crop</i>	<i>Maize</i>	<i>Soya</i>	<i>Silage</i>
Acreage	15.1	7.3	8.0
Cost per 200 lb. unit 1959/60	17s-10d	48s-5d	20s-1d (per s. ton)
Yield, units (× 200 lb.) per acre	20.6	7.8	12.1 s. tons
Cost per 200 lb. unit, 1958/59	14s- 3d	61s- 2d	28s-6d (per s. ton)
Yield, units (× 200 lb.) per acre	20.0	7.5	7.43 s. tons
Cost per 200 lb. unit, 1957/58	12s- 0d	40s-10d	15s-8d (per s. ton)
Yield, units (× 200 lb.) per acre	18.0	8.5	11.25 s. tons

The costs shown are actual cash expenditure on the crop and do not include overheads. At Bvumbwe 25 per cent. of the costs are added as overheads. The figures are mainly useful as an index of the efficiency of production. They are compared in Table III with previous years. High yields per acre are essential if the cost of production is to be kept to a minimum.

Over the years progressively higher yields of maize have been obtained. This has been accomplished by the use of higher-yielding varieties and the adoption of a slightly closer spacing giving a greater plant population. The hybrid white maize, Mthenga, and the yellow variety, Sahara, have been chosen as most suitable for our purposes. Small seed of Mthenga gave a 5 per cent. reduction in yield compared with plants grown from large seed.

Soya, although yields were high when compared with other soya-producing areas, proved too expensive a crop at Bvumbwe. Volstate and Pelican were the highest yielding varieties and tests are to be made with others for higher yields. An alternative crop is also being sought.

A satisfactory legume for a mixed pasture is still required. The management of *Desmodium intortum* and *Stylosanthes gracilis* has proved difficult; they are rapidly eaten out when incorporated in a rhodes grass ley.

One rotation on the original six-course system of the Mixed Farm Unit has been completed. Field G was added to the Farm in 1959/60.

TABLE IV

Rotation of Mixed Farm Unit and Yields per acre from Arable Crops

Field	1954	1955	1956	1957	1958	1959	1960
A	Star Grass ley		Maize Namlenga 3,500 lb.	Soya* 2,086 lb.	Maize Namlenga 4,300 lb.	Rhodes	Grass ley
B		Star Grass ley		Maize Namlenga 2,614 lb.	Soya 1,710 lb.	Maize Namlenga 3,249 lb.	Napier Grass ley
C	Maize Namlenga 2,705 lb.		Rhodes grass ley		Maize Namlenga 3,315 lb.	Soya 1,350 lb.	Maize Mthenga 4,120 lb.
D	Velvet Bean, linseed and wheat	Maize Namlenga 2,200 lb.		Rhodes Grass ley		Maize Mlonda 4,400 lb. Namlenga 3,845 lb.	Soya 1,560 lb.
E	Maize Namlenga 2,000 lb.	Soya 3,046 lb.	Maize Namlenga 3,009 lb.		Napier Grass ley		
F	Beans	Maize Namlenga 3,817 lb.	Soya Volstate 1,492 lb.	Maize Namlenga 3,104 lb.		Rhodes Grass ley	
G	Rhodes	Grass ley	(not part of	Mixed Farm Unit until	1960)		Maize Mthenga 4,547 lb.

Size of each field—8 acres + 1.5 acres.

*Half of Volstate and half of Pelican, which matures ten days later, was planted every year.

The unit is agriculturally sound, producing yields of maize, soya and pasture which compare favourably with other regions.

2. Trial of a Concentrate Feed on Cows

Object.—To compare the effect on milking cows of a concentrate feed containing cotton seed cake with one containing cotton seed filter press cake.

Analysis of the two ingredients:

				Moisture	Crude Protein	Oil
Cotton Seed Cake	..	..	..	5%	44%	7%
Filter Press Cake	..	..	..	2.9%	33.5%	42%

Layout.—Cross-over design. Replicates provided by eight milking cows which were selected in four pairs each at a similar age and stage in their lactation.

Treatments.—Each ration was made up so that 4 lb. contained 0.72 lb. of crude protein. Four lb. of meal was fed for every gallon of milk produced. Maintenance was provided by feeding approximately 50 lb. of silage per day per animal.

Ration A				Ration B			
Maize	..	..	60 lb.	Maize	..	..	48 lb.
Cotton Cake	..	..	24 lb.	Filter press cake	..	..	39 lb.
Rice Bran	..	..	16 lb.	Rice Bran	..	..	13 lb.
TOTAL	..	..	100 lb.	TOTAL	..	..	100 lb.

One animal in each of the four pairs received treatment A for two weeks; the other four animals received treatment B. Then the treatments were changed over and given for another two weeks.

Results.—The milk yield of the cows during the period of the experiment is shown in Table V.

TABLE V
Milk Yield, Concentrate Feed Trial
(*lb. per cow*)

			28 days	Mean
Cotton Seed Cake	..	..	350	25.0
Filter Press Cake	..	..	341	24.4

Difference between treatments not significant.

Although there was no significant difference between the effects of cotton filter press cake and cotton seed cake, the former has certain marked disadvantages. It arrived very lumpy and, due to its high oil content, was very sticky and difficult to break down. The cows refused to take the concentrate when it contained large particles of filter press cake. Therefore, before it can be recommended for extensive use, some means must be found of breaking it down mechanically so that a homogeneous mixture is produced. When it was mixed with rice bran, much of the oil was absorbed and the material became easier to handle. The high oil content of ration B did not appear to have any harmful effect on the cows.

Acknowledgement is made to Messrs. Nyasaland Oil Industries Ltd. who supplied the cakes.

REFERENCES

- Foster, L. J., 1959—"Mixed Farming Systems in Nyasaland."
Nyasaland Farmer and Forester, 5 (1), Dec., 1959.

Unit Farms

The difficulties of devising an experimental approach to the task of integrating the results of experimental work into a farming system are well recognized. The method of Unit Farms has been widely adopted and there are several variations in this approach, each of which has its merits and defects. If the farm is worked entirely with paid labour it becomes an exercise in management and there is no incentive to the worker to become as efficient as possible.

Several Stations have begun Unit Farms with an African in charge who is allowed to retain the profits after deducting any costs for labour, fertilizer, etc., that may be incurred. There is thus an incentive to work hard and to employ family labour as would be done by a farmer. While it is recognized that it is not easy to find the right individual there are many advantages in this method and it is hoped that many practical lessons will be learnt.

There are four of such farms that have been begun, each in a different ecological zone. A preliminary report is given of one using irrigation but the others have not yet been developed to the state of reporting.

UNIT FARM

By D. F. Collings, E.C.G.C.

Any development of irrigation in the Elephant Marsh will involve the settlement on small holdings of a large number of the African population of the area. In an attempt to obtain information on the economic, social and agricultural problems involved, an African family of 2 adults and 2 children has been settled on a four acre irrigated holding on the station.

The Unit operator's previous experience consists of his past work on his own village garden and three years as a labourer on the irrigation area of Makanga.

The holding is laid out on the border check system, each border consisting of $\frac{1}{4}$ acre. This divides the area up into 16 borders, 2 being used in each break of the rotation.

Water is supplied from the station system and is measured through a weir to a set flow of $\frac{1}{2}$ cu. sec.

The rotation has been planned with sugar as the main cash crop. The remaining crops will provide food, a small amount of cash crops and a rest from sugar cane. This rest period is considered necessary until further information is obtained.

The rotation will be changed as and when experience indicates its weak points.

TABLE VI
Unit Farm Rotation

Year				Summer	Winter
1	..	..	..	Maize	Beans
2	..	..	..	Maize	Onions etc.
3	..	..	..	Groundnuts	Maize
4	..	..	..	Cotton	Plant Cane
5	..	..	..	Sugar	Sugar
6	..	..	..	"	"
7	..	..	..	"	"
8	..	..	..	"	"
8 breaks of $\frac{1}{2}$ acre					

This provides for two acres of sugar, two acres of farm crops. One break of sugar will be planted annually and one disposed of.

Should extra labour be required, it will be provided by the station but supervised and paid for at standard rates by the farmer.

All seeds, fertilizer, etc., will be purchased and paid for.

Rent will be set at a given percentage of the capital used in developing the holding and a water tariff will be charged at a rate approximately that which would be charged in any Elephant Marsh Scheme. An interim period from March to November this year has been allowed in which to provide sufficient food and capital for the coming season. This has been very successful.

CHEMICAL WEED CONTROL (CHITEDZE)

In order to economize on labour in the weeding of the bulk fields on stations, experiments are in hand to find the most effective and cheapest spray treatment for controlling weeds in maize and groundnuts. This year's experiment at Chitedze was a 2×3 factorial with three replications under maize and one under groundnuts. The two sprays Fernimine and Agroxone were compared at three rates and times of application, and two controls, no weeding and clean weeding, were included in each block. Weeds were examined and weighed. They comprised mainly the monocotyledons *Eleusine indica*, *Setaria pallide-fusca* and also *Commelina* sp. Against these, Fernimine was more effective than Agroxone and a spray of 1 lb. a.i. per acre in January after the first weeding gave a better control of weeds and yield of maize than a pre-emergence spray of 1 or 2 lb. a.i. per acre. For maize it is probably best, if feasible, to get in an early weeding by hand or machine and then spray to prevent reinfestation of the field. Groundnuts are more susceptible to weeds and weedicide, and a pre-emergence spray of 1 lb. a.i. per acre of Fernimine to help weed control early in the season appears to be the best use of spray for groundnuts in this country.

TABLE I

Effect of Chemical weedicides on Maize and Groundnuts

Varieties: Mthenga (Maize), Mwitunde (G. nuts). Yields: lb./acre grain

<i>Treatment</i>	<i>Weed growth index (gms weed/sample)</i>	<i>Yield Maize</i>	<i>Yield Groundnuts</i>
Not weeded	4,615	1,145	50
Clean weeded	295	4,090***	725
L.S.D. 5%	—	1,695	—
Fernimine (2-4D)	705	3,225	140
Agroxone (M.C.P.A.)	980	3,045	115
L.S.D. 5%	—	510	—
Pre-emergence 1 lb. a.i.†	1,300	2,325	205
Pre-emergence 2 lb. a.i.	1,050	3,140*	60
1 lb. a.i. after 1st weeding	185	3,485**	120
L.S.D. 5%	—	625	—
Coefficient of Variation 16.9%			

†a.i.=active ingredient.

Herbicides

1. IN MAIZE

Object.—To test the herbicides Simazin and 30027 in maize.

Layout.—1/10th acre observation plots were marked out in a field of maize at Bvumbwe. The treatments 1, 2 and 4 lb. per acre of each herbicide, were replicated twice. The variety, Namlenga, was planted on 10th November on the flat in rows 7 feet $\times$ 5 inches $\times$ 1 plant after 2.08 inches of rain had fallen,

The herbicides were applied as sprays three days later after a further 0.80 inches had fallen. This was followed by a comparatively dry period of a week in which only 0.78 inches of rain fell.

The maize had germinated by 19th November but there were heavy cutworm attacks and extensive replanting was necessary. The plots were very weedy by 28th November and neither herbicide appeared to have had any effect. The plots were then weeded by hand.

The spraying treatments were applied again on 8th December. This was followed by frequent showers of rain, totalling 3.42 inches during the week. By 23rd December there was a very marked effect from the herbicide. Results:

Control (Nil). Extremely weedy, the dominant weeds being *Commelina*, *Portulaca*, *Necandra* and *Eleusine*. Weeds were about two feet high.

Simazin. 1 lb./acre. Some weed control but still very weedy, dominant weeds being *Commelina* and *Portulaca*.

2 lb./acre. Dicotyledonous weeds well checked; poor control of old *Commelina* plants which had survived the original ploughing and harrowing.

4 lb./acre. Very good control of weeds including *Commelina*, *Necandra*, *Portulaca* and *Eleusine* and other annual grasses.

30027. 1 lb./acre. Weedy but better than control.

2 lb./acre. Weedy, particularly with *Portulaca*. Not as effective as Simazin against *Commelina*.

4 lb./acre. Weed growth retarded but not as strongly as in Simazin plots.

The effect of the high rate of Simazin was still very marked a month later.

Conclusions

1. The herbicides did not damage the maize,
2. Simazin was more effective than 30027,
3. The only satisfactory rate was 4 lb. per acre,
4. The herbicides were not effective at the first application when they were followed by a period of little rain but were effective when they were followed by a period of heavy rain,
5. Dicotyledons were controlled more easily than monocotyledons.

The cost of the herbicides was prohibitive. Assuming that Simazin would be effective at the reduced rate of 3 lb. per acre the cost of the material alone would be 90s per acre. The untreated maize was cultivated twice up to the end of January, at a total cost of 30s per acre, during the period that the effect of the Simazin persisted.

The cost of the herbicide could be reduced to about 1/7th by applying in bands 1 foot wide over each row, but rows would still have to be cultivated by machine.

2. IN COFFEE

Object.—To test the herbicide Dowpon which contains dalapon (85 per cent. of the active ingredient, sodium 2,2-dichloropropionate) for the control of Bermuda grass (*Cynodon dactylon*) in coffee. Two 1/24th acre plots were selected in mature coffee and sprayed at the beginning of the rains (19–11–59) at the rate of 5 and 10 lb. of Dowpon per acre. The spray was applied low so that the coffee foliage was avoided.

No immediate effect was observed. On the fourth day, by which time 1.82 inches of rain had fallen, the grass was showing a slightly scorched appearance which progressively became more marked for a fortnight after spraying. The effect of the Dowpon upon the *Cynodon* was clearly visible up to 1st February. By 18th December dicotyledonous weeds, particularly *Commelina*, which had been slightly scorched, were growing actively and the tallest weeds were uprooted by hand. By the 1st February both plots were almost smothered in *Commelina*.

The results show that dalopon is a promising herbicide to use on a monocotyledonous weed, such as *Eynadon*, which is difficult to eradicate by hand or machine. It does not however dispense with the need for weeding since broad-leaved weeds are not controlled.

One coffee tree in each plot was sprayed. About 50 per cent. of the leaf area of both trees showed severe scorching within a fortnight of spraying. The trees did not die. Several shoots were completely defoliated and had died by 1st February.

Acknowledgement is made to Messrs. Fisons Pest Control who supplied samples of Simazin, 30027 and Dowpon.

IRRIGATION

(a) Crops and Yields

Following previous practice to meet the requirements of the first object of the irrigation work a list has been compiled in Table VII of crops grown under irrigation during the year together with yields and a mean yield for each crop weighted for acreage. A weighted mean yield and estimate of value is given for each crop over the last three years.

In considering this table it must be borne in mind that, (a) the prices quoted represent the most realistic obtainable but there is not always a guarantee that the crop could be disposed of at that price, (b) there is no certainty that the most suitable varieties and irrigation techniques have yet been found.

(b) Water Requirements

(i) *Measurement of Evaporation.* Recording of open pan and piche evaporimeter has continued at both the old and new sites. Irrigation of experiments was based on the open pan readings at the old site. Penman's formula has been calculated, both directly and from a nomogram, for part of the year and compared with evaporimeter readings.

(ii) *Leaf Area Index.* No leaf area determinations were made during the year.

(iii) *Soil Moisture.* Many oven determinations of soil moisture were made both to ascertain the soil moisture at certain stages of crop growth and to assess the water holding capacity of the soil. These results should be compared with the moisture content of the soil at field capacity which depends on texture. The texture of these soils varies considerably necessitating individual determinations of field capacity for each sample, which is impracticable.

Soil moisture is more usefully expressed as units of volume (such as inches per foot of profile) than on units of weight. To convert determinations by weight to a volume basis, the bulk density (apparent specific gravity) is required. This, like field capacity, varies with texture and is impracticable to determine for each sample taken. Oven determinations of soil moisture have therefore only served to emphasize the textural variability of the Makanga soils; this variability has made interpretation of the results difficult.

Likewise texture differences have made calibration of gypsum blocks in useful units difficult. However, working on the basis that maximum resistance is approximately wilting point and minimum resistance is near field capacity, useful results have been obtained from blocks read with a Bouyoucos meter. In experiments with water rates it has been shown which treatment or treatments maintained the soil at field capacity and enabled more accurate determinations of water requirements to be made than those based on yield data alone when it is not known if depletion of soil moisture reserves has occurred.

(c) Irrigation Experiments—Annual Crops

(i) *Water Requirements of Maize.* Spacing and nitrogen fertilization were introduced as additional factors with water rates in a 3³ design experiment with the object of confirming the water requirement of maize found last year. The treatments were:

TABLE 1
Irrigation Treatments of Maize

<i>Factor</i>	<i>Level</i>			
	0	1	2	
Nitrogen—N	0	250	500	lb./acre Sulphate of Ammonia
Spacing—S	12 ins.	9 ins.	6 ins.	within 3 rows at 3 ft.
Water—W	0.6 through-out (18 ins. applied)	0.6 until tasselling 1.6 for 4 weeks 0.6 there-after (24 ins. applied)	0.6 for 4 weeks 1.2 there-after (31 ins. applied)	X open pan

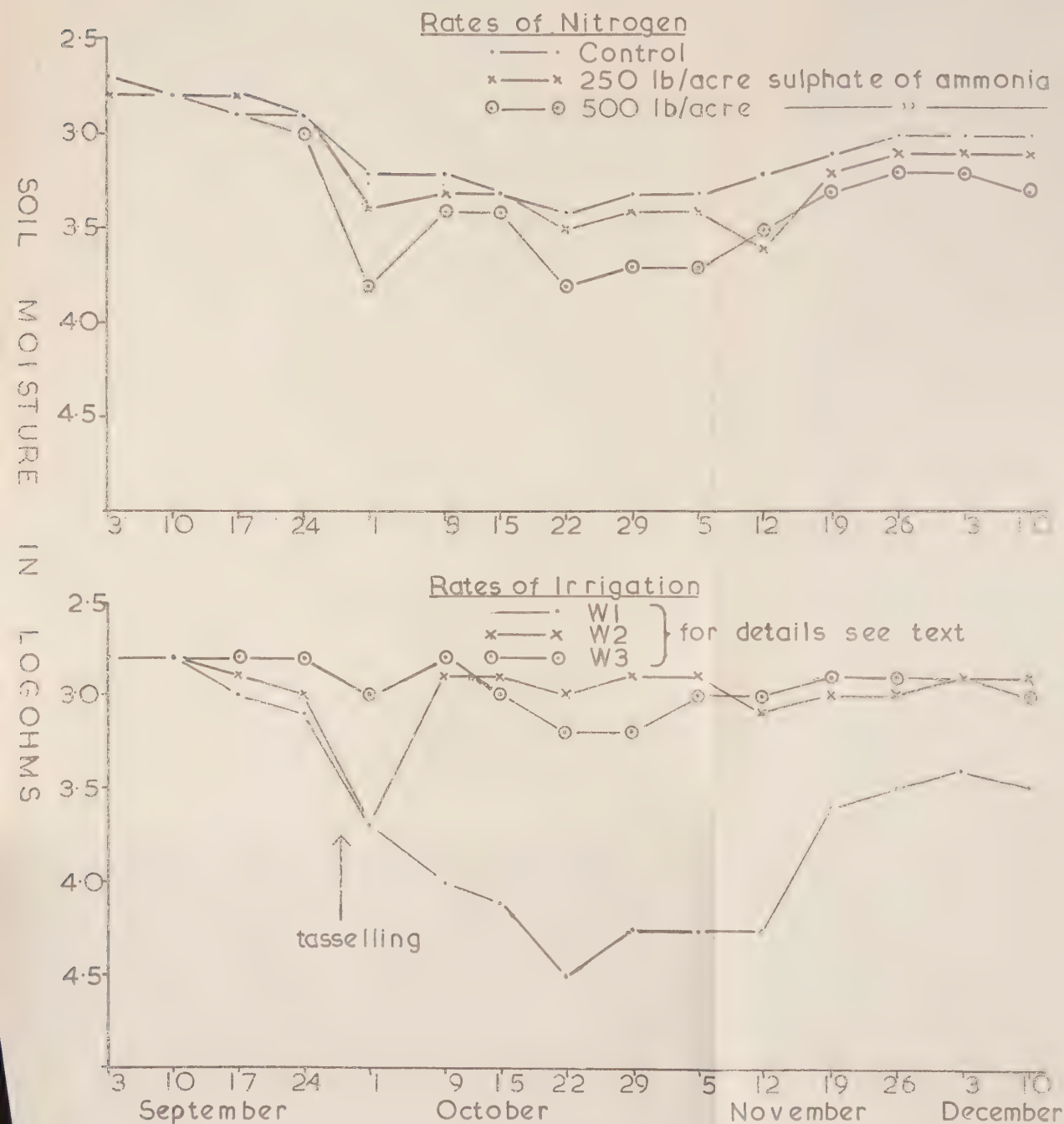
There were no significant yield responses to either spacing or water, in the latter case because the crop drew on soil moisture reserves as shown by the gypsum block readings (*see* Fig. 2) which also confirm treatment W, as the water requirement. There was a response to nitrogen significant at 1 per cent. and a significant interaction between nitrogen and water showing there was no response to nitrogen at the low water rate. Another manifestation of this effect was noted in the gypsum block readings where in Fig. 2 it can be seen that maize at the high nitrogen rate drew more heavily on soil moisture reserves.

TABLE II
Effects of Water and Nitrogen Rates on Yield of Maize
(Yields in lb./acre of grain)

<i>Water</i>				0	1	2	<i>mean</i>
Nitrogen							
0	..	..	..	2,648	2,014	1,927	2,196
1	..	..	..	2,660	2,828	3,592	3,027
2	..	..	..	2,697	3,978	3,350	3,342
mean	..	..	..	2,669	2,940	2,957	—
L.S.D. 5%				Centre of table	945	—	—
				Margins	547	—	—
Coeff. of Variation				—	16.3%	—	—

(ii) *Water Rates on Wheat and Potatoes.* Simple randomized block experiments were conducted on these crops in the dry season to confirm previous findings regarding water rates. Results are given in Table III. With wheat only the highest water rate, a factor $0.6 \times$ open pan, yielded significantly lower than the other rates. Oven determinations of soil moisture a month after harvest could detect no differences in the extent to which the crop under different treatments had drawn on soil reserves: all appeared to have reduced soil moisture to near wilting point in maturing on the reserves, assuming texture to be average.

Figure 2. EFFECT OF VARIOUS RATES OF IRRIGATION AND NITROGEN ON SOIL MOISTURE UNDER MAIZE.



Means of 9 plots each with 3 blocks one at 1ft., 2 ft., and 4 ft
Crop planted 27th July, harvested 28th November.

Figure 3. EFFECT OF VARIOUS SUPPLEMENTARY
IRRIGATION RATES ON SOIL MOISTURE UNDER GROUNDNUTS

Irrigation Rates

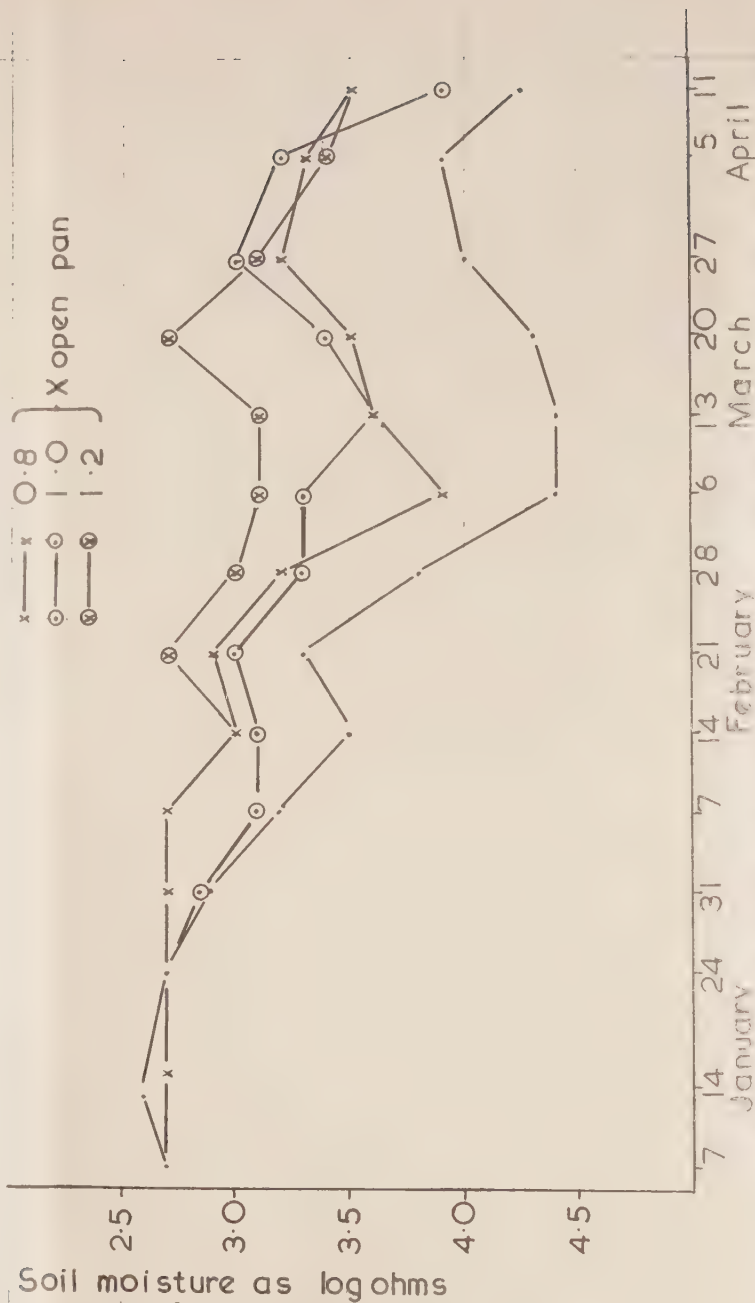
— control

x — 0.8

o — 1.0

⊗ — 1.2

} X open pan



Mean of 7 plots each with 2 blocks one at 1 ft and one at 2 ft. deep.
Crop planted 29th December harvested 17th April.

Significant differences were recorded in the yield of potatoes the lowest rate of water being outyielded by the three highest rates between which there were no differences. Oven determinations of soil moisture at harvest suggested all treatments had depleted soil moisture reserves in maturing, irrigation having been stopped some weeks before harvest. The extent of this depletion varied, being least at the highest rate, indicating that this rate was more successful in maintaining soil at field capacity.

(iii) *Water Rates on Groundnuts.* An experiment similar to those described above for wheat and potatoes was carried out on this crop. Treatments (factors) and yields are given in Table III. There were no significant differences in the yield of groundnuts but gypsum block readings presented in Fig. 3 show supplementary irrigation at a factor of 0.8 was adequate to maintain soil at field capacity until mid-February when the requirements rose to a factor of over 1.2. The crop did not appear to draw very deeply on moisture reserves: the limit was somewhere between 2 and 4 feet.

A simple factorial experiment on soya bean included two times of planting and two water rates (control and $\times 1.2$). There were no significant differences. Yields at the different water rates are given in Table III.

(iv) *Manurial Experiments.* There are long term manurial trials laid down on three irrigation fields to check whether continuous intensive cropping will deplete fertility. The only responses observed were a significant response of one ton per acre of onions compared with a control yield of 3 tons/acre to an application of 100 lb./acre of muriate of potash and a highly significant reduction in yield of cotton from the application of farm yard manure at 10 and 20 tons per acre: yields from these applications were 1,478 and 1,238 pounds of seed cotton per acre respectively while control yield was 2,060 pounds per acre.

Neither wheat, soya, grams or groundnuts showed any response to the above treatments nor to application of nitrogen or phosphate. No depletion of fertility is apparent yet.

TABLE III
Yields of Various Crops at Different Water Rates

Crop Factor	1959 Dry Season					1959/60 Wet Season		Perennial Crops
	Wheat lb./acre	Potatoes tons/acre	Onions tons/acre	Carrots tons/acre	Beetroot tons/acre	Groundnuts lb./acre	Soya lb./acre	
Nil	—	—	—	—	—	861 (nil)	2,177 (nil)	—
.2	547 (6)	—	—	—	—	—	—	—
.3	507 (8)	—	—	—	—	—	—	—
.4	545 (10)	7.5 (8)	—	—	—	—	—	—
.5	401 (12)	—	—	—	—	—	—	—
.6	282 (12)	8.9 (10)	4.1 (12)	6.7 (12)	7.6 (12)	—	—	—
.8	—	10.2 (12)	4.9 (15)	10.7 (15)	8.0 (15)	935 (4)	—	8.8 (42)
1.0	—	9.7 (14)	6.4 (18)	11.7 (18)	9.6 (18)	1,020 (8)	—	8.7 (65)
1.2	—	10.4 (16)	—	—	—	1,014 (12)	2,467 (15)	8.0 (77)
1.4	—	—	—	—	—	—	—	9.1 (90)
1.6	—	—	—	—	—	—	—	8.3 (112)
L.S.D. 5% ..	95	1.8	1.3	3.7	2.4	184	404	—
Coeff. of Variation ..	17.3%	12.8%	19.4%	29.7%	22.1%	17.9%	22.2%	—

Figures in brackets after yields are the total amounts of irrigation water applied in inches for each treatment.

(v) *Cotton—Supplementary Irrigation* (written in collaboration with D. F. Collings, E.C.G.C.).

All attempts to increase cotton yields by irrigation have failed though yields of over 2,000 lb./acre have been obtained apparently as an after effect of dry season irrigation. There is some evidence of correlation between yields and January/February rainfall. The experiment described below was an attempt at boosting yields by supplementary irrigation at this time. Dry planting had previously given better results in comparison with preplanting irrigation and was also included. The design was a 3×5 factorial with split plots, planting techniques being allocated to the main plots and supplementary irrigation treatment allocated to the sub-plots. Treatments and results are given in Table IV. It should be noted that the S.E. of main plot treatments has only 2 degrees of freedom.

TABLE IV
Yield of Seed Cotton under Supplementary Irrigation

Treatment Description								Irrigation water applied	Yield seed cotton lb./acre
1.	Dry planting followed by irrigation at $\times 1.6$ until 3rd Jan.	..						12 in.	2,546
2.	6" before planting followed by irrigation at $\times 1.0$ until 3rd Jan.							6 in.	2,174
3.	12" before planting followed by irrigation at $\times 0.4$ until 3rd Jan.							12 in.	2,068
L.S.D. 5%								—	824
Coeff. of Variation								—	18.9%
A.	Irrigation at 1.6 for January	..						8 in.	2,139
B.	" " " for February	..						6 in.	2,462
C.	" " " for January and February	..						14 in.	2,250
D.	" " " for February and March	..						10 in.	2,280
E.	" " " for March	..						4 in.	2,174
L.S.D. 5%								—	410
Coeff. of Variation								—	14.4%

There are no significant differences in yield between the treatments though both dry planting and any treatment with February irrigation has increased yields.

(vi) *Irrigation Technique*

Water Requirements at Germination. An experiment was planted with a number of crops in the 1959 dry season to compare planting with the soil at field capacity with dry planting followed by a gradual build up of soil moisture. The treatments laid out in a randomized block were:

- | | | |
|----|--|--|
| 1. | Control field capacity at planting; irrigate at $\times 0.6$ | |
| 2. | Dry Plant; irrigate at 0.8 | } until total water equals treatment 1 when irrigation drops to $\times 0.6$. |
| 3. | " " " at 1.0 | |
| 3. | " " " at 1.0 | |
| 4. | " " " at 1.2 | |

The total amount of water applied on all treatments was 14 inches.

TABLE V
Water Requirement at Germination

Crop	Control yield	Treatment Yields as % of Control			
		1	2	3	4
Wheat	Straw only	100	82	136	125
Linseed	386 lb./acre	100	101	116	95
Soya	221 lb./acre	100	67	69	86
Beetroot	2.83 tons/acre	100	132	189	127
Carrots	5.47 tons/acre	100	109	109	115

The results are shown in Table V; the differences are not significant but the yields of soya, beetroot and carrots have been corrected for stand by covariance before which there were significant differences between treatments in soya and beetroot. The uneven stands are thought to have been caused by poor irrigation resulting from inaccurate levelling though they might have been treatment effects. As a tentative conclusion dry planting gave as good or better yields than pre-irrigation except for soya beans.

A second experiment on soya beans consisted of single observation plots. The result tended to confirm that soya prefers preplanting irrigation.

Frequency of Irrigation. Standard irrigation practice on experiments is to apply 2 inches of water when the deficit on the water balance sheet reaches that amount. It was suspected that shallow rooted crops might benefit from, or at least economize water with, smaller applications allowing smaller deficits to accumulate. An experiment to test this was put down in the 1959 dry season. Onions, beetroot and carrots were the subject of a 2×3 factorial experiment in which three water rates, factors of 0.6, 0.8 and 1.0, were applied in combination with two frequencies, 1 inch deficit and 2 inches deficit. The results of the water rate treatments only are given in Table III.

Beetroot gave no significant response to water rates, with carrots both higher rates significantly outyielded the lowest, and with onions, the highest rate significantly outyielded both lower rates. There were no differences in any crop between the frequencies but, although the interaction was not significant, in each case at the lower irrigation rate irrigating at 1 inch was better than irrigating at 2 inches while at the higher irrigation rate irrigating at 2 inches was best. This means that if the full water requirement cannot be met to obtain maximum yield, better use can be made of a lower rate by irrigating more frequently.

(vii) *Miscellaneous.* Crops after cotton. Growing cotton under irrigation presents certain rotational problems as it is liable to remain in the ground until 31st July which is late for planting a winter crop. Observations were therefore made on a number of crops planted after a cotton crop. These were wheat, sesame, linseed, green grams, Canadian Wonder beans, carrots, beetroot, soya and maize. The resultant yields and dates of harvest are included in Table VI for field J. Sesame, green grams, maize, beetroot and carrot all yielded reasonably, grams being earliest and carrots the most valuable.

TABLE VI
Yield and Date of Harvest of Various Crops after Cotton

<i>Crop</i>	<i>Yield per acre</i>	<i>Date harvested</i>
Wheat	Destroyed by birds	—
Linseed	276 lb.	9th November
Green grams	1,270 lb.	12th November
Carrots	4.2 tons	7th December
Beetroot	3.0 tons	8th December
Soya	800 lb.	11th December
Sesame	910 lb.	12th December
Maize	2,340 lb.	19th December

Depth of Rooting. An attempt was made in the 1959 dry season to measure the depths to which various crops utilized soil moisture by taking regular soil samples for moisture content at different depths after irrigation stopped. The results, to be accepted with caution, were:

Carrots	}	..	..	..	30 inches
Potatoes					
Onions					
Groundnuts	..	..	..	..	36 inches
Beetroot	..	..	..	..	42 inches
Wheat	}	..	..	..	48 inches or deeper
Linseed					
Beans					

Varieties. Significant differences were found between yields of a number of wheat varieties but none raised yields to an economic level. Details are given in Table VII.

TABLE VII
Yield of Wheat Varieties

<i>Variety</i>	<i>Yield lb./acre</i>
Kenya	989
Gabo A9	921
Gabo A6	915
Rhod No. 2	881
Kenya Governor	881
Gabo	754
Angola	571
L.S.D. 5 %	407
Coeff. of Variation	27.1%

Two potato varieties were compared and Robyn significantly outyielded Pimpernel: yields were 12.2 and 6.9 tons per acre respectively.

Observations on time of planting potatoes suggested yields fell off consistently from 7.2 tons per acre with 7th May planting to 0.8 ton per acre when planted two months later.

(d) Perennial Crops

(i) *Lucerne*. The object of growing this crop is to provide a ley break in an irrigation rotation and provide fodder should cattle feature in the farming system of any irrigation scheme. An experiment comparing water rates was in operation during the year and, although not completed, yields of hay for the 12 months period are given in Table III. These yields are from 8 cuts. The variety obtained from South Africa was sown in June, 1959, to replace a previous crop which failed largely due to dodder.

(ii) *Sugar cane*. The third ratoon cut of the 20 varieties ex Alimenda in museum plots was taken between May and August, 1959. Average yields of all cuts are:

1956	1957	1958	1959	Total
Plant cane	1st ratoon	2nd ratoon	3rd ratoon	—
52 tons/acre ..	53 tons/acre ..	22 tons/acre ..	38 tons/acre ..	165 tons/acre

The best 9 varieties have been selected for further work: the best, CO331, gave 832 tons cane per acre in the first four cuts and all exceeded 190 tons/acre.

TABLE VIII

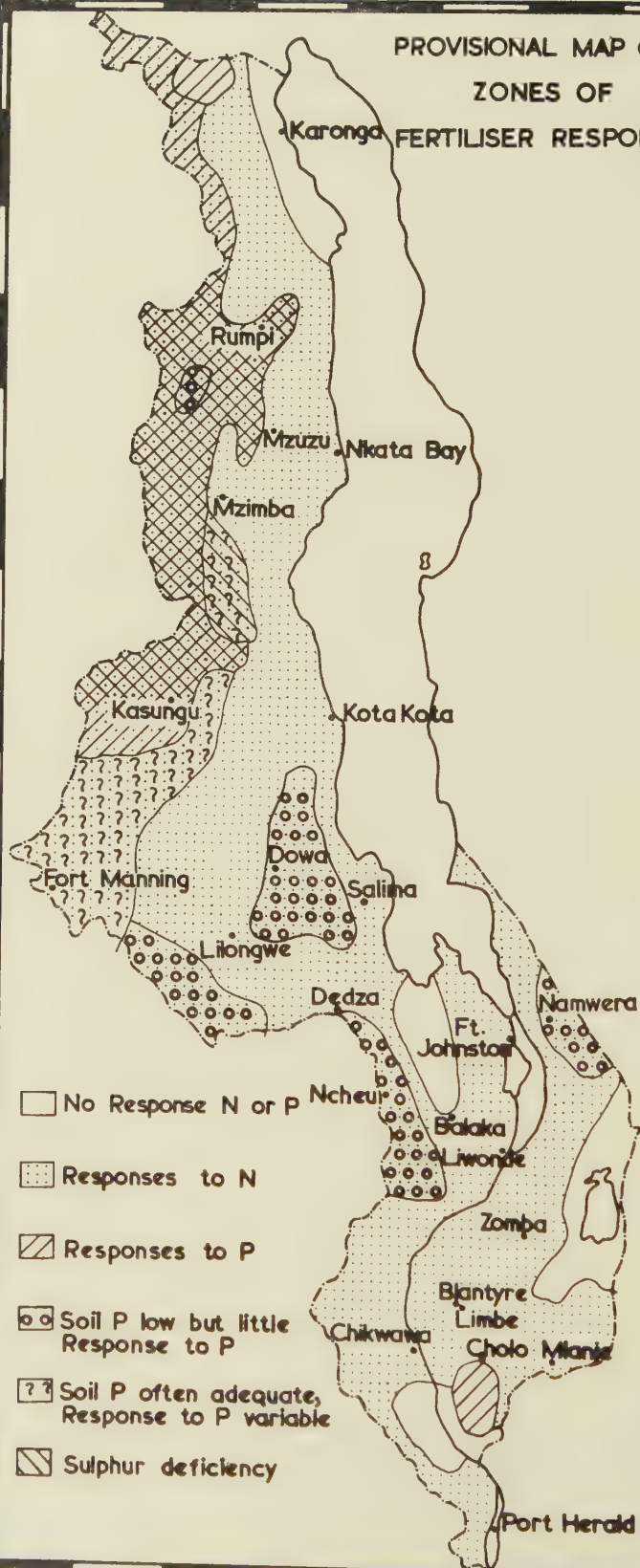
Yields and Value of Irrigated Crops at Makanga

Crop	Field	1959 Dry Season					To Date Since 1956			
		Date planted	Acres	Yield/acre	Weighted mean yield	Total acres	Weighted mean yield	Total acreage	Price	Gross value per acre
Maize	L	28/7	1.00	2,857 lb.	2,857 lb.	1.00	2,928 lb.	2.36	1d	£12
Soya ..	B	July	.15	990 lb.	—	—	—	—	—	—
	J X	17/8 17/6	.04 .04	800 lb. 221 lb.	823 lb.	0.23	823 lb.	0.23	£30/ton	£12
Red Beans	B	5/5	0.33	1,440 lb.	1,232 lb.	0.51	832 lb.	1.38	£30/ton	£13
	J	17/8	0.18	850 lb.	—	—	—	—	—	—
Green Gram	B	8/5	0.33	480 lb.	759 lb.	0.51	759 lb.	0.51	£40/ton	£15
	J	17/8	0.18	1,270 lb.	—	—	—	—	—	—
Linseed	J	17/8	0.18	276 lb.	296 lb.	0.22	524 lb.	1.58	1/-lb.	£44
	X	17/6	0.04	386 lb.	—	—	—	—	—	—
Wheat	C	21/5	.55	504 lb.	—	—	—	—	—	—
	C	21/5	0.09	854 lb.	494 lb.	1.64	650 lb.	5.17	£30/ton	£10
	K	13/5	1.00	457 lb.	—	—	—	—	—	—
Onions	A	12/8	.88	3.6 tons	3.7 tons	0.96	7.3 tons	2.20	3d/lb.	£183
	W	—	.08	5.2 tons	—	—	—	—	—	—
Carrots	X	17/6	.04	5.3 tons	—	—	—	—	—	—
	J	17/8	.07	4.2 tons	6.7 tons	0.19	11.4 tons	0.49	£8/ton	£91
	W	—	.08	9.7 tons	—	—	—	—	—	—
Beetroot	X	17/6	0.4	2.8 tons	—	—	—	—	—	—
	J	17/8	0.4	3.0 tons	5.7 tons	0.16	8.8 tons	0.31	£8/ton	£70
	W	—	0.8	8.4 tons	—	—	—	—	—	—
Potatoes	P	7/5	.73	7.9 tons	7.9 tons	0.73	7.5 tons	0.87	3d/lb.	£186
Sesame	J	17/8	.18	910 lb.	910 lb.	0.18	910 lb.	0.18	4d/lb.	£15

TABLE VIII—(Continued)
Yields and Value of Irrigated Crops at Makanga

Crop	Field	1959/60 Wet Season					To Date Since 1956			
		Date planted	Acres	Yield/ acres	Weighted mean yield	Total acres	Weighted mean yield	Total acreage	Price	Gross value
Cotton	K	26/11	.83	2,284 b.	—	—	—	—	—	—
	O	2/12	0.92	2,267 lb.	2,041 lb.	2.67	1,604 lb.	9.57	5d/lb.	£33
	C	27/11	0.92	1,597 lb.	—	—	—	—	—	—
Maize	—	—	—	—	—	—	2,731 lb.	6.10	1d/lb.	£11
Groundnuts	B	18/11	.30	773 lb.	913 lb.	1.22	898 lb.	3.42	5d/lb.	£19
	L	29/12	.92	958 lb.	—	—	—	—	—	—
Soya ..	P	19/12	.80	2,323 lb.	2,200 lb.	1.16	1,787 lb.	3.16	£30/ton	£27
	B	18/11	.30	1,846 lb.	—	—	—	—	—	—
Hibiscus	K	—	.09	940 lb.	940 lb.	0.09	1,281 lb.	0.24	£40/ton	£26
Rice ..	X	—	.26	1,012 lb.	1,012 lb.	0.26	1,012 lb.	0.26	2d/lb.	£8
<i>Perennial Crops</i>										
Lucerne	N	—	1.00	8.6 tons	8.6 tons	1.00	7.4 tons	2.00	£20/ton	£148
Sugar cane	Y	1956	0.38	38 tons	38 tons	0.38	4.1 tons	0.38	£50/ton	£205

PROVISIONAL MAP OF ZONES OF FERTILISER RESPONSE



SOIL SURVEY

Chikwawa—Ngabu

(See folded maps in back pocket)

Between Chikwawa and Chiromo both the Rift Valley and the Shire River within it follow a south-easterly direction. An area lying obliquely to this, covering 290 square miles on the west bank of the Shire, was selected for soil survey. It extends from close to the Shire-Zambezi watershed, which forms the border with Mozambique, in its south-western corner, to within two miles of the Shire in the north-east (Fig. 1). This area includes parts of most of the main natural regions found in Chikwawa District, with the exceptions of the narrower east bank zone and of Elephant Marsh, which has been surveyed in detail previously (R. Smith *et al.*, "The soil survey and land classification report of the Elephant Marsh area, Lower Shire Valley, Nyasaland," Hunting Tech. Serv., London, 1957, 88 pp.). The environmental conditions described should therefore prove representative of other parts of the Lower Shire Valley.

RELIEF AND GEOLOGY

There are five major physiographic divisions, shown on Fig. 2. In the south-west is an area of close dissection, with moderate slopes and frequent hills. This is formed from basalt lavas of the Karroo System, with two small areas of Karroo sandstones. Near its north-eastern boundary this region lies at an altitude of 400-500 feet, rising gently south-westwards to 1,000 feet. A low, discontinuous scarp, following the line of the Panga fault, forms the boundary with the second region, a belt of gently undulating country at 300-450 feet. This is underlain partly by coarse calcareous sandstones of the Lupata Series (Cretaceous) and partly by Karroo basalts. In both these regions a large majority of the drainage courses, especially the minor valleys, follow a north-easterly direction.

The gently sloping zone merges gradually into an extensive plain of drift deposits. The overall eastward slope of this is less than 10 feet per mile. Well-borings reveal that the drift is more than 200 feet deep in most places, but that the rock surface beneath it possesses considerable relief. In particular, an extension from the north-west of a ridge of Basement Complex rocks (*see below*) has been located from a soil pit, two outcrops, and one well boring (*see Fig. 2*). Within this plain, level *dambo* areas, low-lying and subject to seasonal flooding, form a fourth division; these are outwash zones for the Mwanza and for the Nkombedze wa Fodia and its right bank tributaries.

In both these latter regions, air photographs show indications of active alluviation. South and west of the Nkombedze the river courses are impermanent, lines of trees indicating abandoned channels; a number of stream courses terminate on the plain before reaching the Nkombedze. On the few occasions in the year when flow takes place in these channels the water sinks into the drift, depositing its load on the bed and banks to form low levees. North-east of the Nkombedze, however, deposition is not at present active; this river acts as a barrier, carrying any material which reaches it to the south-east. A second area of current deposition occurs where the Mwanza ceases to flow in a well-defined bed, spreads out, and sinks into its own alluvium. West of the main road, however, it has cut a short way below the drift plain, and deposition is confined to a narrow flood-plain.

At the northern margin of the area is a fifth region, consisting of broad, low ridges formed by Basement Complex rocks, mainly hornblende-biotite gneisses. Both structural and relief features follow the south-easterly direction typical of this section of the Rift Valley. A north-easterly trending swarm of dolerite dykes has been intruded into these rocks. This region becomes more extensive immediately to the north, in the area west of Chikwawa.

CLIMATE

Climatic conditions are relatively uniform over the whole of the Lower Shire Valley. Temperatures remain high throughout the year, ranging from a monthly mean of 69° in July to 84° in November. The mean diurnal range, 24°, exceeds the annual range of 16°; in November, immediately preceding the rains, maxima exceeding 100° are common.

Mean annual rainfall is 32 inches of which 77 per cent. falls in the four months December–March. Variability is large; once in ten years the total is expected to be either below 16.5 inches or above 47.4 inches (H. L. Manning, in R. Smith *et al.*, op. cit.). In addition to this, the majority of falls are of high intensity. Short period records indicate that mean annual evaporation is between 55 and 65 inches. This is slightly lower than on Upper Shire and Lake-shore stations (67–78 inches), probably because lower wind velocities outweigh the effect of higher temperatures. Evaporation normally exceeds rainfall for at least eight months of the year.

The net result of these conditions is that rainfall effectiveness is very low. Besides its agricultural significance, this has important consequences on soil formation. The soils which have developed show close affinities with those normally found under considerably drier conditions, with a rainfall of 20 or even 15 inches.

SOILS

The area is of particular pedological and agricultural interest, containing both one of the most fertile soils in Nyasaland, the "makande" soil, and also considerable areas marginal for cultivation. A previous more extensive survey (A. Muir and I. Stephen, "The superficial deposits of the Lower Shire Valley, Nyasaland", *Col. Geol. Min. Res.* 6, 1956, 391–406) has shown a further distinctive feature, namely the correspondence of soils developed on drift deposits to variations in the rock types lying to the west and south-west, from which the drifts have been derived. The present more detailed survey has confirmed this finding.

Nineteen natural regions, areas in which the environmental conditions are relatively uniform, have been distinguished; these are shown on the map (in back pocket). The subdivision is on the basis of landforms, soils, and vegetation. The main soil series will first be described, followed by accounts of the physical environment in each region.

(1) THE TOMALI SERIES

A large number of soil profiles examined on the drift plain were sufficiently similar in characteristics to justify grouping as one soil series. This will be defined as the Tomali Series, after the village of that name amid the most extensive area of it. It has previously been described as "Grey-brown (forest) soils" (A. Muir *et al.*, "The soils of the Shire Valley", Appendix No. 12 to the Shire Valley Project Report, 1954). The essential features of this series are that it is *formed from drift deposits, dark grey brown to dark brown* in colour, and with *massive* structure. Within the series four variants, or soil types, have been distinguished, on the basis of parent material, texture, and consistence (*see regional descriptions below*).

The series is developed on a depositional plain, the surface slopes of which do not normally exceed $\frac{1}{2}^\circ$. The profile is deep, the subsoil passing imperceptibly into parent material. The topsoil is 10YR 3/1 very dark grey, 3/2 very dark grey brown, or 2/2 very dark brown; this passes into 7.5YR 3/2 dark brown in the subsoil. The lower subsoil may remain at this colour, sometimes with a faint grey mottle, or less commonly become redder, reaching the 5YR hue. Texture is variable, with sandy loam and sandy clay loam the most common; depositional bedding is characteristic, giving abrupt changes in texture, including beds of almost entirely coarse sand, but there is no systematic variation of texture with depth. The soil is stoneless, but may contain a small proportion of fine gravel. Despite the very low relief a catena may be distinguished, varying in drainage status. Commonest are profiles with free drainage (no mottling) or imperfect drainage (mottled in depth). Less frequent is impeded drainage, with a mottled subsoil and heavier texture, often clay loam, which grades into poorly drained *dambo* clays. Permeability is normally moderate or rapid.

Sandier and freely drained horizons have a completely massive structure, and are very hard when dry. Slightly heavier horizons have a characteristic structure: in standard nomenclature this is medium to coarse (1–2 inches) angular blocky of moderate or strong grade; the cracks, however, whilst well developed, remain very narrow in dry soil, whilst the peds are extremely hard. This gives the soil as a whole a massive tendency, becoming hard to cultivate when dry.

The topsoil and subsoil are weakly acid to neutral, pH 6.0–7.2; the lower subsoil becomes alkaline, with the pH normally 7.0–8.0 and sometimes rising to 8.5 below 60 inches. Concretionary matter may be absent, but calcium carbonate concretions are commonly found in depth, and a few fine ferric iron concretions have twice been recorded. The base saturation is normally 70–90 per cent., with complete saturation also common, indicating conditions of weak leaching. Exchangeable bases are high, varying with the clay percentage but otherwise without large or systematic change with depth in the profile. The nutrient status is good, with medium nitrogen, normally 0.1–0.2 per cent. in the topsoil, high phosphate, and high to very high potash, often above 2.0 m.e. per cent. In freely drained profiles the organic matter content falls from 2–5 per cent. in the topsoil to less than 0.6 per cent. beneath, but with imperfect drainage it may rise again in depth to as much as 2.5 per cent., with irregular variations. Soluble salts are normally low, occasionally rising below 60 inches to 0.1 per cent., giving marginally saline horizons. The base exchange capacity per 100 gm. of clay ranges from 40 to 80 m.e. per cent., suggesting illite with some montmorillonite as the predominant clay minerals; this is confirmed by previous X-ray examinations of two profiles (Muir and Stephen, *op. cit.*), in which illite formed 60–80 per cent. of the clay minerals.

Thus the genetic conditions in the soil are those of very weak leaching, giving way to deposition in depth only where the drainage becomes imperfect. Agriculturally, a moderate to high fertility is combined with difficult tillage properties.

(2) THE MAKANDE SERIES

The cultivation properties of this soil are sufficiently distinctive to have earned it a vernacular name of restricted application, "makande". This name is in general use, and was retained by Muir *et al.* (*op. cit.*). The essential features of the series are that it is *formed from drift derived from basic rocks, strongly structured, easily friable when dry and very sticky when wet, with calcium carbonate deposition in depth.* Whilst possessing certain affinities with the "black cotton soils" formed from similar parent materials in India and elsewhere, it differs in having a browner colour and lighter texture.

The series is developed from shallow or deep colluvial deposits derived from basic lavas, or directly from these lavas; it occupies gentler slopes and concave valley floors. The topsoil is 10YR 2/2 very dark brown or slightly blacker; this invariably becomes paler with depth, the subsoil and lower subsoil being between 7.5YR 3/2 dark brown and 5YR 3/3 dark reddish brown. The most common texture is sandy clay loam, including both coarse and fine sand; sandy loams, clay loams, and clays are also found. Clay is 20–45 per cent. and silt is often high, 10–30 per cent., with a silt/clay ratio of 0.4–0.8. Where derived directly from bedrock, stones may be present. Permeability is moderate to rapid, and drainage free.

Characteristic of the series is a strong blocky structure of a distinctive nature, in which the larger, most strongly developed, structural units are themselves divided into smaller blocky peds; in some cases three superimposed sizes of peds can be distinguished, the largest, $\frac{1}{2}$ –2 inches, having a columnar tendency. A consequence of this is the ease with which the dry soil can be cultivated.

The reaction is close to neutral in the topsoil, rising with depth to about pH 8.5. Calcium carbonate concretions commence at between 12 and 60 inches and increase with depth, often passing into calcrete. In a quarry exposure one mile south of Ngabu no base to the calcrete was seen at 100 inches. The topsoil is weakly leached, but base saturation becomes complete in the subsoil and beneath. Nutrient status and exchangeable bases are high. The high base exchange capacity indicates montmorillonite as the dominant clay mineral, which is confirmed by previous X-ray examination (Muir and Stephen, op. cit.); this contrasts with the Tomali soils, and accounts for the very different structure and consistency of the two series. As is commonly the case in dark-coloured tropical soils, organic matter is only lowish, 3–4 per cent. in the topsoil, the dark colour being due to its association with montmorillonitic clay minerals. When freely drained the series is only slightly saline, with total soluble salts close to 1.0 per cent.; east of the area surveyed, closer to the Shire, drainage impedance becomes more common, and both soluble salts and exchangeable sodium may become high, giving conditions transitional toward salinized soils.

The contrast in properties between the Tomali and Makande series forms a clear instance of the influence of parent material on soil formation, since they occur under an identical climate and with similar drainage conditions. The much greater basicity of the Makande parent material causes the tendency for deposition of calcium carbonate in depth, probably latent in the Tomali series, to become strongly expressed as concretionary horizons. Under conditions of weak leaching in the upper horizons, the same influence causes the formation of different types of clay minerals during weathering; this in turn affects the field properties, resulting in the ease of tillage of the Makande soil.

(3) THE RIFT VALLEY DAMBO SERIES

Although possessing many similarities with *dambo* soils developed at higher altitudes, the poorly drained soils of the area differ in certain respects, and will be distinguished as a separate series. These soils are *poorly drained black heavy clays developed at low altitudes*. The series is formed from fine textured alluvium on level outwash plains. The topsoil is typically 10YR 3/1 very dark grey, becoming 10YR 2/1 black in the subsoil; in depth the colour may either remain black or become mottled. The proportion of clay is normally 45–60 per cent., and silt is high, 18–30 per cent.; the topsoil is lighter than the subsoil, otherwise there is no systematic variation of texture with depth. Drainage is poor but the upper horizons dry out seasonally.

A strong coarse angular blocky structure is present, sometimes with a columnar tendency. Strong clay skins occur on ped surfaces, often showing markings formed by differential movement of the peds against each other during expansion and contraction.

The topsoil is almost neutral, pH 6.5–7.0, and the lower horizons neutral to weakly alkaline, pH 6.8–8.0. Organic matter is 3–5 per cent. in the topsoil. A few fine iron concretions, either black or yellowish red, are usually present in the lower horizons. Due to the poor drainage the profile is not leached. Nutrient status is good, with potash high. As in the Makande series, the dark colour is associated with only lowish organic matter, 2–5 per cent. in the topsoil falling to 0.5–1.0 per cent. below, but in this case the colour is due to the presence of iron in ferrous form. The soil is non-saline to about 40 inches, below which both soluble salts and exchangeable sodium rise considerably. As with the Tomali series, the fertility status permits cultivation, but drainage difficulties are here added to the intractable nature of the clay.

Of frequent occurrence in the Nkombedze *dambo* are areas with gilgai features. This term is applied to various forms of micro-relief developed on heavy textured poorly-drained soils (S. A. Harris, "The classification of gilgaied soils: some evidence from Northern Iraq", *Jour. Soil Sci.* 10, 1959, 27–33; with references). In this region the ground is covered with circular depressions spaced at 20–40 foot intervals, having sides of 4°–6° and a depth of approximately one foot; they are locally known as "matawale" (=pools). In the centres of most of the hollows are vertical-sided pits, oval or rectangular, from 4 to 18 inches across, and 10–15 inches deep. Grass grows taller and more densely in the hollows than on the raised areas between, but in the pits, or over a small area in the hollow centres where pits are absent, there is no vegetation. The soil is heavier in the hollows than on the raised areas, with approximately 5 per cent. more clay, and the structure is correspondingly coarser. On the raised areas the uppermost two inches have a fine to medium structure and a loose, soft consistence when dry.

Representative profile descriptions of the above three series are as follows; analytical data are given in Tables I and II.

Major soil group: semi-arid brown. *Series:* Tomali. *Type:* Tomali fine sandy clay loam. *Drainage:* imperfect. *Location:* west of main road, two miles south of Mwanza bridge. *Altitude:* 280 feet. *Relief:* level. *Parent material:* sandy drift deposits derived from Karroo sandstones and Basement Complex hornblende-biotite gneisses. *Vegetation:* savanna of medium trees with thicket patches.

0–6 inches	10YR 3/1 very dark grey (moist), fine sandy clay loam; weak medium blocky structure, moderate permeability, micaceous, many grass roots; merging boundary
6–40 inches	7.5YR 3/2 dark brown, fine sandy clay loam; massive, hard when dry, micaceous, few roots, merging boundary
40–70 inches	7.5YR 3/2 dark brown with common faint fine greyish mottle, sandy loam; massive, compact but less hard than above, few roots, no reaction; sharp boundary
70–80 inches	7.5YR 5/6 strong brown, with common black grains, coarse sand; single grain structure, very rapid permeability.

Major soil group: semi arid-brown. *Series:* Makande. *Drainage:* free. *Location:* 200 yards east of crossroads near Goma Village. *Altitude:* 320 feet. *Relief:* gentle even $\frac{1}{2}^\circ$ slope. *Parent material:* drift derived from Karroo basalt lavas. *Land use:* entirely under cultivation, sorghum and cotton.

0- 7 inches	10YR 2/2 very dark brown (moist), clay loam; strong fine-medium blocky structure, main peds 1/10 inch, weakly aggregated into $\frac{1}{2}$ - $\frac{3}{4}$ inch units; easily friable when dry, very sticky when wet, rapid permeability, many grass roots; merging boundary
7-18 inches	colour as above, fine sandy clay loam, high in silt; basic $\frac{1}{4}$ inch blocky peds partly aggregated into 1-2 inch structures with columnar tendency; roots common, weak reaction; clear boundary
18-56 inches	7.5YR 3/2 dark brown, sandy clay loam, fine sand dominant above 33 inches, coarse sand below; strong 2 inch columnar structure subdivided into $\frac{1}{2}$ -1 inch blocky; strong reaction, very few roots; clear boundary
56-72 inches	as above but with many $\frac{1}{4}$ - $\frac{1}{2}$ inch calcium carbonate concretions, increasing with depth, violent reaction.

Major Soil Group: hydromorphic. *Series:* Rift Valley Dambo. *Site drainage:* poor, seasonally flooded. *Profile drainage:* poor. *Location:* west of main road, half a mile south of Nkombedze bridge. *Altitude:* 270 feet. *Relief:* level, with gilgai micro-relief, profile on raised area. *Parent material:* fine textured alluvium. *Vegetation:* tall grassland.

0- 5 inches	10YR 3/1 very dark grey (moist), clay, with some coarse sand present; strong medium angular blocky structure, strong clay skins, abundant roots and rhizomes; merging boundary
5-40 inches	10YR 2/1 black, heavy clay; very strong coarse angular blocky structure, strong clay skins, very stiff when wet, permeability very slow, few roots; merging boundary
40-60 inches	10YR 2/1 black with common faint dark brown and yellowish red mottling, heavy clay; structure as above; few hard black rounded iron concretions.

NATURAL REGIONS

REGIONS WITH TOMALI SERIES SOILS

1. *Drift plain: Tomali series fine sandy loam to sandy clay loam.* The regions found on the drift plain differ primarily on the basis of soil characteristics, and are therefore coincident with subdivisions of the Tomali series.

The soils of the first region are formed of drift derived from Karroo sandstones and Basement Complex hornblende-biotite gneisses. Deposition is not at present active, consequently local relief is very slight or absent; the south-eastern part of the region in particular has an extremely uniform appearance on air photographs. Sandy loam and sandy clay loam textures greatly exceed all others, with fine sand normally dominant over coarse. The silt proportion is 10-25 per cent., with a high silt/clay ratio, 0.5-1.0.

A distinctive vegetation formation occurs on most of the Tomali series soils, consisting of savanna with thicket patches and open grass glades. The grass species form good indicators of local drainage variations. On freely drained soils *Urochloa pullulans* is dominant; it is characterized by a markedly uniform height of 24-30 inches, giving the appearance of having been mown off at this height. *Digitaria milaniana* occurs in association with it on freely drained areas. With imperfect drainage scattered plants of *Setaria palustris* appear, and these become numerous where impeded drainage occurs. Poorly drained patches have the dambo grasses described below. The commonest tree species are *Acacia nigrescens*, *A. spirocarpa*, *Adansonia digitata*, *Albizzia harveyi*, *Boscia salicifolia*, *Combretum apiculatum*,

Cordyla africana, *Dalbergia melanoxylon*, *Hyphaene ventricosa*, *Lonchocarpus capassa*, *Sterculia africana*, and *S. appendiculata*. *Combretum imberbe* and *Sclerocarya birrea* are common on sites with impeded drainage but also occur on freely drained areas; *Kigelia pinnata* indicates impeded drainage, and *Acacia xanthophloea* is confined to river banks and poorly drained sites. Cultivation has in the past been limited to areas with access to water supplies from the Mwanza.

2. *Drift plain: Tomali series, coarse sandy loam to sandy clay loam.* This region is similar to the previous except that the coarse sand fraction is equal to or predominant over the fine (see Table I). The soil structure is massive, but less hard when dry than in the preceding region. The vegetation has largely been cleared for cultivation, but the same species as those described above are found.

3. *Drift plain: Tomali series, compact coarse sandy clay loam, with sandy thickets.* The drift in this region is derived from Lupata sandstones. Deposition is active, with numerous spreads of sandier soil, occupied by thickets. The coarse sand fraction normally exceeds the fine; silt is lowish, with a silt/clay ratio frequently below 0.3. These textural features result in a singularly intractable soil, massive and extremely hard when dry. The vegetation is similar to that described above, with *Acacia nigrescens* and *Dalbergia melanoxylon* particularly common.

4. *Drift plain: Tomali series, compact coarse sandy clay loam, thickets absent.* This region is similar to the above except that spreads of very sandy soil are absent. In the only soil pit examined, calcrete occurred below 64 inches. The vegetation formation is tree savanna, mainly *Acacia nigrescens* and *Dalbergia melanoxylon*, with bushes of *Combretum ghazalense* characteristic. This and the preceding region have been uninhabited in the past owing to lack of water supplies. Recently a number of boreholes have been sunk, and cultivation of limited areas has commenced, although the soil presents tillage difficulties.

5. *Drift plain: Tomali series, loamy coarse sand.* The main areas of coarse very sandy drift have been grouped together to form this region. These include the flood-plains of the Pwadze and of the Mwanza west of the main road, narrow levees along the right bank tributaries of the Nkombedze, isolated patches derived from former deposits of this type, and an extensive area in the Lengwe Game Reserve. Within the two latter zones there exists a micro-relief of irregular mounds of the order of 15 feet width and 1-3 feet high, with sides of $\frac{1}{2}^{\circ}$ - 3° . The soils are loamy sands to sandy loams, with coarse sand dominant, but with sufficient clay to be very hard when dry. The Mwanza flood-plain differs in being almost pure coarse sand, and loose when dry.

The region is occupied by a thicket-forest formation similar to that found in patches in the above regions. It possesses a discontinuous canopy of medium trees, below which is a dense shrub stratum at a height of 5-20 feet, which inhibits grass growth. The commonest shrub is *Anisotes sessiliflorus*. Many of the tree species are the same as those listed above for the savanna, but in the Lengwe Game Reserve area *Pterocarpus antunesii* is the most common. The soil is unsuitable for cultivation.

REGIONS WITH MAKANDE SERIES SOILS

6. *Gently undulating: Makande series.* The area is occupied by Makande soils, formed on gentle slopes of $\frac{1}{2}^{\circ}$ - 1° . These are almost entirely under cultivation, for sorghum and cotton, and the natural vegetation has been cleared. *Cordyla africana* and *Boscia salicifolia* is characteristic of the series, in association with *Sterculia appendiculata*, *Zizyphus mauritiana*, and bushes of *Combretum ghazalense*; *Calotropis procera* is a common weed on village sites.

7. *Valley floors: Makande series.* Within areas of Karroo basalts, with stony soils, certain valley floor areas have become opened out. These are not flood-plains but slope inwards at $2^{\circ}-\frac{1}{2}^{\circ}$, only a small strip in the centres being level. The soils are Makande series, becoming blacker in colour and heavier in texture toward the valley centres, with clay loams and clays common. They form islands of cultivation, difficult of access across the surrounding dissected country.

8. *Catena of stony ridges and Makande series.* This region is formed by a series of low sub-parallel ridges and valleys, 500–1,000 feet apart and with maximum slopes of $1\frac{1}{2}^{\circ}-2^{\circ}$. Makande soil occupies the valley floors up to about 1° , at which point it gives way fairly abruptly to shallow soil, stony and in some cases with calcrete. This is occupied by almost pure stands of *Colophospermum mopane*. Where cultivation has been extended a short way onto this shallow soil the cotton crops show a striking decrease in height towards the mopane woodland.

9. *Drift plain: association of Makande and Rift Valley Dambo series.* Where material of basaltic origin forms the drift plain a zone occurs in which patches of dambo soil are irregularly distributed amid Makande series. This region extends in places eastwards to the Shire.

10. *Flood plains amid Makande soils.* The main rivers amid region 6 have narrow flood-plains, bounded by clear bluffs. Soils are similar to the Makande series but with imperfect drainage, and remain moist for a longer period of the year.

RIFT VALLEY DAMBO SERIES

11. Besides the two extensive zones associated with the Mwanza and Nkombedze, these soils are found in two situations; firstly on outwash plains where minor streams join the Pwadze flood-plain, and secondly on low-lying patches amid the drift plain. Included in the latter are many small areas amid the Tomali series, not delimited separately on the map. The soil is covered by tall dense tufted grassland, with *Setaria palustris* and *Isachaeum brachyatherum* as the main species. A few scattered short trees of *Acacia campylacantha*, *Combretum ghazalense*, *C. imberbe*, *Kigelia pinnata*, or *Sclerocarya birrea* may be present. Although of high fertility, most of this soil is not cultivated owing to tillage and drainage difficulties.

REGIONS WITH STONY SOILS

The remaining regions have in common that the majority of their soils are too shallow or stony for cultivation. The vegetation on all except region 17 consists of a short tree and bush scrub, with *Combretum apiculatum*, *C. ghazalense*, *Diospyros kirkii*, and *Pterocarpus brenanii* widely distributed, and *Terminalia sericea* common on valley floor margins. There is a sparse grass cover.

12. *Moderately dissected Karroo basalts.* The majority of the surface consists of gentle $1^{\circ}-3^{\circ}$ slopes, often irregular in detail, with hills rising above them. Along the valleys open stretches (region 7) alternate with narrow incised portions. Many stones lie on the ground. In addition to the tree species given above, this and region 14, both formed of basalt lavas, contain *Acacia nigrescens*, *Colophospermum mopane*, *Combretum imberbe*, *Dalbergia melanoxylon*, and *Lonchocarpus capassa*.

13. *Ridges of Karroo sandstones.* Closely spaced parallel ridges and valleys, with slopes of $10^{\circ}-15^{\circ}$, are aligned in a north-easterly direction; they are formed from the Upper Sandstones of the Karroo system. The soil is bouldery or stony.

14. *Gently undulating, Karroo basalts.* Slopes are mainly $1^{\circ}-2^{\circ}$, with limited areas of 5° . Valleys are not incised, but have limited areas of shallow basaltic drift in their floors, forming cultivable patches.

15. *Gently undulating, Lupata sandstones.* Leading into the main north-eastward flowing streams are numerous small lateral tributary valleys; between these are short, sub-parallel, convex ridges with maximum slopes of 2° – 4° . The region is formed from reddish calcareous sandstones of the Lupata Series (Cretaceous). On the ridges the soil is gravelly and shallow, with rock at 12 inches or less. The valley floors contain a coarse sandy clay loam, about 24 inches deep, poor but cultivable. A small outlying part of this region lies amid the drift plain, a low very gentle oval rise with radial drainage. In addition to the five species common on all the stony regions, *Bolsanthus speciosus* is found.

16. *Valley floors amid Lupata sandstones.* The floors of the larger valleys within region 15 contain flood-plains with alluvial deposits, and have been mapped separately. The soils are sandy but probably cultivable, although access to water presents difficulties.

17. *Gently undulating, wooded.* The distinguishing feature of this region is its woodland vegetation. Over most parts *Colophospermum mopane* is dominant, with *Acacia nigrescens* as the only other tree; low bushes of *Dalbergia melanoxylon* occur within the woodland, and open patches are occupied by *Combretum ghazalense*. To the north-east, near the margin with the drift plain, areas with *Acacia nigrescens* as the dominant appear. Slopes are mainly $\frac{1}{2}^{\circ}$ – 1° , and the soil a shallow gravelly sandy clay loam.

18. *Basement Complex ridges.* Broad stony ridges with slopes of 5° – 8° run in a south-easterly direction, following the strike of the hornblende-biotite gneisses. The intrusive dykes produce low narrow ridges, with a surface of boulders, cutting obliquely across the main lines of relief. In addition to those given above, a characteristic tree is *Sterculia quinqueloba*.

19. *Hills.* The main hills have been mapped separately. All are low, typically 100–300 feet with slopes of 10° – 15° . The two steep isolated hills adjacent to region 18 are formed of quartzite.

ACKNOWLEDGMENTS

In the course of this survey assistance has been received from the Department of Geology, in identifying rock specimens, and from the Federal Herbarium, Salisbury, in determining plant species. Analytical data was supplied by Bvumbwe laboratories under the direction of Dr. C. V. Cutting. The field survey was carried out with the co-operation of Mr. J. W. Reed, Agricultural Officer, Chikwawa. In the initial stage of the survey assistance was received from Mr. G. Jackson.

The Agro-Ecological Survey of Nyasaland

The majority of soil survey work during the year has been concerned with this survey, which has as its objects to assess the agricultural resources of Nyasaland and to map their distribution. Soil maps on a scale of 1:250,000 will be produced. The field soil survey has been completed for Northern Province and for that part of Central Province lying north of the latitude of Lilongwe. Over 3,500 miles of road and track have been covered, making mile-by-mile observations of landforms, soils, vegetation, and agriculture, and 335 soil profiles have been examined. Air photograph interpretation of Northern Province is in progress.

As an interim measure pending the completion of the survey, a Preliminary Soil Map of Nyasaland, on a scale of 1:2,000,000, has been published. Fifteen soil groups are represented, with brief notes for each group on soil characteristics, parent-material, relief, altitude, climate, vegetation, and agriculture, together with typical analytical data. Reference should also be made to the map of Fertilizer Response Zones contained in the Report of the Agronomist (p. 24 above).

TABLE I
Mechanical Analyses

<i>Series and Type</i>	<i>Depth ins.</i>	<i>Gravel* %</i>	<i>Coarse Sand %</i>	<i>Fine Sand %</i>	<i>Silt %</i>	<i>Clay %</i>	<i>Texture</i>
Tomali fine sandy clay loam	0-6	0	17	32	25	26	Fine sandy clay loam
	6-24	1	17	43	15	25	Fine sandy clay loam
	24-40	0	14	55	11	20	Fine sandy loam
	40-70	1	40	33	12	15	Sandy loam
	70-80	2	79	12	4	5	Coarse sand
Tomali coarse sandy clay loam	0-4	0	28	28	23	21	Sandy clay loam
	4-10	1	34	31	10	25	Sandy clay loam
	10-22	1	33	28	9	30	Sandy clay loam
	22-48	1	34	22	9	35	Coarse sandy clay loam
	48-65	1	32	28	8	32	Sandy clay loam
	65-75	2	33	21	11	38	Coarse sandy clay
Tomali compact coarse sandy clay loam	0-6	1	50	31	5	14	Coarse sandy loam
	6-18	1	49	22	5	24	Coarse sandy clay loam
	18-52	1	50	21	4	25	Coarse sandy clay loam
	52-64	2†	54	21	3	22	Coarse sandy clay loam
	64-70	4†	59	20	3	18	Coarse sandy loam
Tomali loamy coarse sand	0-6	1	53	28	9	10	Loamy coarse sand
	6-18	0	53	26	8	13	Coarse sandy loam
	18-24	2	49	28	7	16	Coarse sandy loam
Makande	0-7	1	13	19	28	40	Clay loam
	7-18	1	12	37	21	30	Fine sandy clay loam
	18-33	0	2	45	23	30	Fine sandy clay loam
	33-56	1	45	15	7	33	Coarse sandy clay loam
	56-65	5†	46	15	7	32	Coarse sandy clay loam
	65-72	10†	40	16	14	30	Coarse sandy clay loam
Makande	0-6	1	21	17	19	43	Clay
	6-27	1	24	13	18	45	Clay
	27-40	54†	18	47	17	18	Fine sandy loam
	40-90	84†	26	18	19	37	Clay loam
Rift Valley Dambo (gilgai mound)	0-2	0	18	16	19	47	Clay
	2-5	0	16	14	18	52	Clay
	5-22	0	13	15	18	54	Clay
	22-40	0	14	13	18	55	Clay
	40-60	0	9	14	19	58	Clay
Rift Valley Dambo (gilgai hollow)	0-3	0	12	11	22	55	Clay
	12-18	0	6	6	27	61	Clay

*Expressed as percentage of fine material (less than 2 mm. diameter)

†Calcium carbonate concretions.

PUBLICATIONS

Young, A. "Preliminary soil map of Nyasaland (on a scale of 1:2,000,000)." Govt. Printer, Zomba, 1960, 8 pp., with map.

Young, A. "Soil movement by denudational processes on slopes." *Nature*, Vol. 188, 1960, No. 4745.

TABLE II
Chemical Analyses

Series and type	Depth ins.	pH	Organic matter (=Org.C × 1.724)	Carbon %	Nitrogen %	C/N ratio	Exchangeable bases m.e. %					Base exchange capacity m.e. %	Base saturation	Phosphates, p. p. m.		Carbonates	Total soluble salts %
							K	Ca	Mg	Na	Total			Available (NH ₄ F extract)	Reserves (HCl, NH ₄ F extract)		
Tomali fine sandy clay loam	0-6	6.1	4.7	2.7	0.19	13.9	2.25	14.4	5.4	0.12	22.1	20.0	100	158	695	—	0.07
	6-24	6.3	1.7	1.0	0.07	13.6	0.33	9.4	2.2	0.26	12.3	14.1	87	31	343	—	0.04
	24-40	6.6	0.1	0.1	—	—	0.33	8.8	2.0	0.17	11.3	14.0	81	13	211	—	0.04
	40-70	7.0	0.5	0.3	—	—	0.25	7.0	1.6	0.14	8.9	10.0	89	20	280	—	0.05
	70-80	7.7	2.1	0.1	—	—	0.07	1.4	0.4	0.11	2.0	2.2	91	15	233	—	0.04
Tomali compact coarse sandy clay loam	0-6	7.3	1.6	0.9	0.07	12.8	0.95	6.8	1.6	0.09	9.4	8.0	100	66	233	—	0.06
	6-18	6.7	1.2	0.7	0.06	12.2	0.33	9.8	2.4	0.17	12.7	11.2	100	18	70	—	0.03
	18-52	7.1	0.1	0.0	—	—	0.28	9.4	2.2	0.26	12.1	14.2	85	—	57	—	0.04
	52-64	8.0	0.0	0.0	—	—	0.40	71.0	5.0	0.46	76.9	26.3	100	4	141	++	0.10
	64-70	8.6	0.0	0.0	—	—	0.22	121.0	40.0	0.58	161.8	18.8	100	—	110	++	0.09
Makande	0-7	6.3	2.8	1.6	0.09	17.3	1.15	22.8	7.0	0.24	31.2	36.3	87	62	396	—	0.09
	7-18	7.6	1.6	0.9	0.08	10.8	0.64	88.3	12.0	0.29	101.2	32.5	100	18	84	+	0.11
	18-33	7.9	1.2	0.7	—	—	0.65	186.0	12.4	1.40	180.4	32.5	100	18	501	++	0.11
	33-56	7.9	1.0	0.6	—	—	0.55	29.0	13.0	0.28	42.8	21.3	100	13	202	++	0.10
	56-65	8.3	0.7	0.4	—	—	0.50	34.0	13.0	0.31	47.8	21.3	100	12	211	++	0.12
	65-72	8.2	0.6	0.4	—	—	0.65	208.0	51.0	1.90	261.5	22.5	100	37	312	++	0.19
Rift Valley Dambo (diger mound)	0-2	7.4	1.8	1.1	0.09	11.3	0.95	24.0	9.0	0.31	34.3	20.0	100	66	299	—	0.06
	2-5	7.4	1.6	0.9	0.08	10.6	1.15	20.0	6.8	0.33	23.3	28.8	98	9	53	—	0.06
	5-22	8.1	1.4	0.8	0.07	10.7	0.75	27.6	9.2	2.90	40.4	36.2	100	22	150	—	0.09
	22-40	7.6	1.4	0.8	—	—	0.90	47.0	19.0	12.00	78.9	36.5	100	22	220	+	0.97
	40-60	7.7	1.1	0.6	—	—	0.80	45.0	10.0	14.00	69.8	35.0	100	18	229	+	1.92

ENTOMOLOGY

Stored Product Investigations

The conditions of storage and control of pests of stored products were investigated in Limbe/Blantyre, Balaka and other centres. In some places control of pests left much to be desired and advice was given, while in others modifications of the existing control measures were recommended. There has been a general improvement since these investigations were started and, as a rule, the control measures taken by the larger export firms are now adequate, but a regular inspection of produce is necessary. Several sheds in Limbe, previously badly infested due to inadequate control measures, are now in a clean condition due to the following up of advice given, and co-operation by the traders has been good.

There is an increasing awareness of the dangers of allowing insect pests to multiply unchecked. This has led to the wider use of elementary precautions (such as not leaving unfumigated produce near a fumigated stack) and an increasing use of fogging machines, and malathion, Lindane and pyrethrum sprays. It is now realized by many who did not realize it before that in this country fumigation of produce, except when exported immediately, is not sufficient without a regular fogging or spraying schedule.

Empty railway trucks were found to be a potential source of infestation of produce, and firms have been persuaded to spray them before loading their fumigated produce.

There was some indication that moths were more prevalent and widespread in grain stores than in previous years, the major moth pests recorded being:

Sitotroga cerealla Oliv., The Angoumois Grain-moth.

Ephestia kuhniella Zell., The Mediterranean Flour-moth.

Ephestia cautella Walk., The Cacao Moth.

Corcyra cephalonica Staint., The Rice Moth.

Others recorded included *Plodia interpunctella* Hb., although this moth was scarce and only at Balaka were several specimens found. In Limbe only a single adult was found. Previously this species was recorded by Salmond as a scarce moth in Nyasaland and found only at lake-shore levels. *Celama squalida* Stgr. was recorded from maize cobs at Balaka.

The chief coleopterous pests recorded were:

Sitophilus oryzae L., The Rice Weevil.

Tribolium confusum Duv.

Tribolium castaneum Hbst.

Latheticus oryzae Waterh.

Dinoderus minutus F.

Rhizopertha dominica F.

Oryzaephilus surinamensis L.

Cryptolestes minutus Oliv.

Tenebroides mauritanicus L.

Acanthoscelides obtectus Say, Bean Beetle.

Callosobruchus maculatus F., Bean Beetle.

Of these species the three first named are commonest in maize, groundnuts, etc., and *S. oryzae* is the most serious coleopterous pest of stored grain. *Lasioderma serricorne* F. was recorded only in tobacco and very few specimens were discovered; however, no search was made for this beetle in particular and it was reported as serious on tobacco farms in some areas.

A survey of the pests of stored products has been commenced in Limbe/Blantyre. This is designed to collate information on the state of produce sheds and the incidence of the different pests. It is hoped to extend the survey in the future to other main centres in Nyasaland.

Zomba Insect Collections

The dry, spirit and slide reference collections require many months of work before they can be regarded as satisfactory. A collection of several thousand insects from the Lower River is being incorporated and the main collection is being reorganized. In the Lower River collection are at least 30 species new to the Zomba collections, a number previously unrecorded in Nyasaland and several new to science. A number of agricultural and other pest insects, not previously in the collections, have been incorporated this year, and a number of previously unidentified insects have been identified.

In due course lists of the insects in the collection will be published.

Notes on Pests

Recorded inquiries on insect pests numbered 123.

Paederus rufocyanus Bernh. (Staphylinidae), which causes vesication when in contact with the human skin and may cause blindness, appears to have been commoner than usual this season. It was recorded chiefly in May and June this year mainly in the highland areas of Central Province.

Phymateus viridipes St. (Acrididae) was abundant this year in the Shire Highlands, particularly in the Chileka area. The drier season appeared to favour this pest which, like the Elegant Grasshopper, *Zonocerus elegans*, has a wide range of host-plants and is gregarious in the hopper stage. It was found attacking maize, coffee and many ornamental hedges and flowering shrubs in late February and March. By mid-March most of the hopper bands had completed their development and dispersed.

The Lantana-bug, *Orthezia insignis* Browne (Coccidae), was especially troublesome this season on ornamental plants and hedges in Zomba. More than twenty plant species were found to be attacked, *Tecoma stans* and Jacaranda being among the worst infested. The sooty mould associated with this insect was very marked in bad infestations. The coccid itself was found to be remarkably resistant to the commoner insecticides and drastic pruning together with the application of a mineral oil seemed to be the only means of achieving a control.

Laphygma exigua Hubn. (Noctuidae), an Army-worm, was common in March in the Shire Highlands where many caterpillar swarms were seen feeding mainly on grasses, but little damage to crops in the region was reported.

Notes on other pests will be found under the appropriate Crop Sections: Oil Seeds, p. 40; Cotton, p. 67; Coffee, p. 149; and Cocoa, p. 157.

In addition, articles were produced for the Seventh Commonwealth Entomological Conference and the First Federal Science Congress. The first of a series of illustrated pamphlets (Hemiptera on Cotton) on agricultural insect pests of Nyasaland is in the press while two others are in preparation (Lepidoptera on Cotton and Stored Product Pests).

PLANT PATHOLOGY

New Records

The following new records were made during the year:

Coffea arabica L.—coffee:

Armillaria mellea (Fr.) Quel—Root rot.

Leptosphaeria coffeicola Maubl—Leafspot.

Cosmos bipinnatus:

Glomerella cingulata (Stonem) Spauld & Schrenk—petal blight.

Dianthus caryophyllus L.—Carnation:

Uromyces dianthi (Pers) Niessl—Rust.

Eriobotrya japonica—loquat:

Entomosporium sp.—leafspot.

Eucalyptus sp.:

Physalospora sp.—leafspot.

Phyllosticta sp.—leafspot.

Gerbera jamesoni Hook—Barberson daisy:

Phyllosticta gerbericola Batist—leafspot.

Gmelina arborea L.:

Mycosphaerella sp.—leafspot.

Periconia byssoides Pers ex Schur—leafspot.

Lactuca sativa L.—Lettuce, var. London Cos:

Septoria lactucae Pass—leafspot.

Lettuce mosaic virus.

Lycopersicon esculentum Mill—tomato:

Phytophthora infestans (Mont) de Bary—Late Blight.

Medicago sativa L.—Lucerne:

Pseudoplea trifolii (Rostr.) Petr.—leafspot.

Mucuna pruriens D.C.—Buffalo bean:

Cercospora sp.—leafspot.

Pennisetum typhoides Stapf & Hubbard—Bulrush millet:

Fusarium sp.—leaf blight.

Phaseolus vulgaris L.—French bean:

Elsinoe phaseoli Jenk—Pod canker.

Psidium guajava L.—Guava:

Glomerella psidii (Del) Scheld—leafspot.

Ascochyta sp.—leafspot.

Ricinus communis L.—Castor bean:

Alternaria ricini (Yoshi) Hansford—leafspot.

Rosa spp.—Rose:

Sphaceloma rosarum (Pass) Jenk—Anthracnose.

Rottboelia exaltata L:

Piricularia grisea (Cooke) Sacc—leafblight.

Solanum panduraeforme E. May:

Phyllosticta sp.—leafspot

Theobroma cacao—Cocoa:

conidial *Glomerella cingulata* (Stonem) Spauld & Schrenk—leafspot and pod rot.

Viola odorata L—Violet:

Alternaria violae Gall & Dorset—leafspot.

Voandzeia subterranea Thouars—Bambarra groundnut:

Cercospora canescens Ell & Mart—leafspot.

Pseudoplea trifolii (Rostr) Petr—leafspot.

Sclerotium rolfsii Sacc.—Wilt.

Zinnia elegans L:

Alternaria zinniae Pape—leafspot and petal blight.

Xanthomonas nigromaculans f. sp. *zinniae* (Takimoto) Hopkins & Dowson—bacterial blight.

The Pathologist would like to express his gratitude to the Director and staff of the C.M.I. for their continued help in identification of specimens. He would also like to express his gratitude to Mr. G. C. Martin of the Federal Ministry of Agriculture for help in identification of nematodes.



